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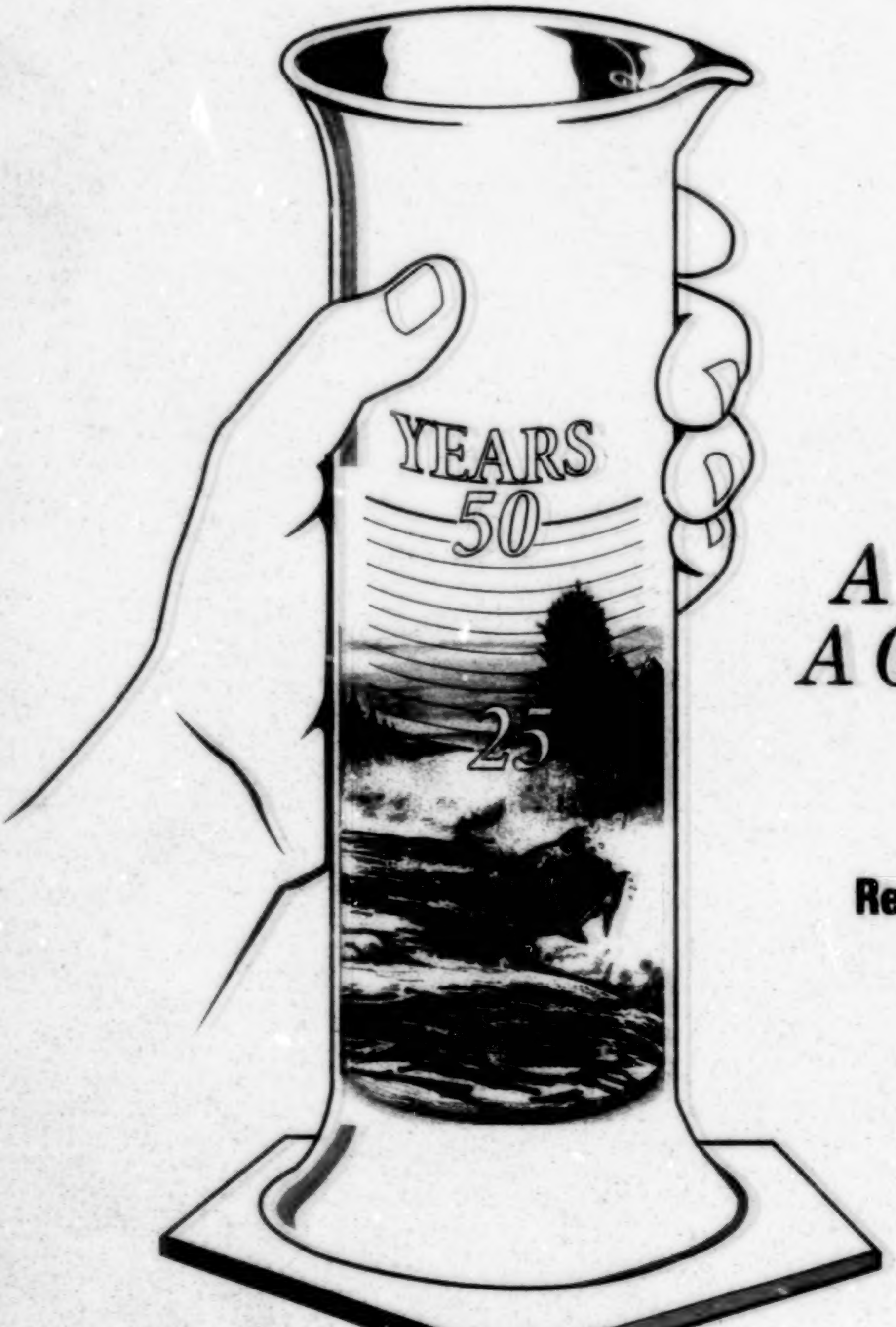
Proceedings of the 50th Annual Pacific Northwest Fish Culture Conference



A Proud Past—
A Golden Future

December 7-9, 1999

Renaissance Madison Hotel
Seattle, Washington

Conference Hosted By
U.S. Fish and Wildlife
Service, Region 1

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50TH ANNUAL PACIFIC NORTHWEST FISH CULTURE CONFERENCE

Preface

The U.S. Fish and Wildlife Service is proud and privileged to host the 50th annual Pacific Northwest Fish Culture Conference. The Service has a long and distinguished history and looks forward to innovative new applications for fish culture and hatcheries in the future. Fish culturists and scientists from private, State, Tribal and Federal facilities in the Northwest have always needed and used this unique conference as a forum to exchange mutually-beneficial ideas, techniques, and science to improve the various products that hatcheries have provided. This year we have added an opportunity for the "back-bone" workers in fish culture to use the "Innovation Station" to share their innovative ideas without the burden of a formal presentation.

The Organizing Committee selected this year's theme to coincide with the "Golden Anniversary" of the Northwest Fish Culture Conference, and to pay tribute to those who have gone before us. The original sponsors were the Bureau of Commercial Fisheries (National Marine Fisheries Service), Bureau of Sport Fisheries (U.S. Fish and Wildlife Service), Washington Department of Fisheries, Washington Department of Game, Fish Commission of Oregon, and the Oregon Game Commission. Several of these agencies have changed names, reorganized, or restructured, but the spirit, comradery and science have continued.

To this year's participants: we welcome you to a "Proud Past - A Golden Future"!

These Proceedings contain abstracts and talks presented at the conference. They are unedited, contain progress reports of uncompleted programs, and, as such, should not be considered a formal, peer-reviewed publication. Mention in these Proceedings does not indicate approval, recommendation, or endorsement of any proprietary product or material.

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Session I:

History and Vision for the Future

Session Chair:

Speros Doulos
USFWS
Little White Salmon NFH Complex

V

THE COLUMBIA RIVER DEVELOPMENT PROGRAM: ORIGIN, HATCHERIES, LABS, PERSONALITIES, SUCCESSES, FAULTS

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Presentation

The Columbia River Development Program was incorporated into the U.S. Corps of Engineers budget to mitigate for the loss of mainstream spawning areas from the construction of Columbia River and Snake River dams. Al Kemmerick was appointed administrator of this program by the U.S. Fish and Wildlife Service in 1948, and he vigorously supported the construction of salmon hatcheries along the Columbia in Washington, Oregon, and later in Idaho. These 25 hatcheries each had a capacity of not less than 25 million chinook salmon smolts per year, some as much as 50 million, and the diet demands to rear these fish on animal liver and fish viscera would exceed national supplies – hence a salmon nutrition laboratory was authorized in 1950 and was completed by 1953 to determine the nutrient requirements of salmon and to develop a satisfactory diet for hatchery use. Roger Burrows was also expanding his diet formulation tests at the Leavenworth hatchery at that time and was cooperating with Tom McKee and Wally Hublou at the Seafoods Lab at Astoria for use of cannery fish viscera into production diets. Lauren Donaldson and Earl Norris at the College of Fisheries in Seattle had completed some work on an enzyme partially hydrolyzed fish tissue diet to rear trout in the school hatchery. The outcome of this diet was the world-famous Donaldson Trout which spread around the world.

John Halver was hired in 1950 to design, build, equip and staff the Salmon Nutrition Laboratory at Cook, Washington, and was given the mission of determining enough nutritional requirements of salmon to formulate an adequate salmon production diet within five to eight years (the time when most of the expanded hatchery program would be active in the Columbia River system). Scientists were hired with specialties in vitamin, protein, lipid, mineral, and carbohydrate biochemistry and were augmented with enzymologists, histopathologists, tracer chemists, and experimental laboratory technologists.

The lab went into full-scale operation in 1953. Monthly staff meetings were used to discuss recent findings and project new efforts in research. Regional and hatchery managers were invited to attend these meetings and suggest demanding current research needs. The hatchery systems then consisted of multiple raceways of fish fed extruded soft diets made of Burrows diet (1/3 liver, 1/3 spleen, 1/3 salmon viscera, bound with 2% salt). Large freezers were present at each hatchery to hold frozen supplies coupled with grinders, mixers and extruders for the diets. About this time, a sockeye salmon virus was found to be carried in the salmon viscera and it wiped out the sockeye salmon program at Leavenworth. McKee came up with a pasteurization process which was adopted the next year, and the salmon virus problem was eliminated. Still these diets were expensive and difficult to produce at different hatcheries; oxidized material occurred in the freezers, and the fish material often varied in composition. Millions of salmon smolts were reared successfully on these diets for many years, however. During the period 1957-1959, protein, amino acid, vitamin and fat tentative requirements for chinook salmon were published and the commercial fish feed industry rapidly expanded. Lyle Branchflower, Seattle, made a fish diet and heat treated it to kill disease organisms; Thorleif Rangen, Idaho, produced a pellet diet made from fish meals and agricultural by-products plus a vitamin and trace mineral supplement; Don Nelson also made pelleted diets in Utah; and Jesse Clarke made dry diets in New Mexico, and later joined Moore to produce the Moore-Clark frozen diets at LaConner, Washington. The large freezers at the many hatcheries were soon filled with these frozen pellets made from hydrolyzed fish waste or from fish flesh and combined with grain flours, fats and supplements. Many state and federal hatcheries adopted the frozen pellet diets.

The U.S. Fish and Wildlife Service and some state agencies contracted for salmon production diets with specifications for ingredients and for levels to be present in the formulations. Inspectors were hired to oversee production at the contractor sites. Diets were tested at new hatchery laboratories; Burrows moved to Entiat and later to Abernathy to build the Diet Development Laboratory. Expansion of the nutrition effort was also made by building the Hagerman Field Station with its 200 troughs of constant temperature water, and the Marrowstone Field Station with its saline and freshwater mixing capabilities. Both of these today are large stations with many capabilities to test diets, toxicity, smolting, seawater conversion, etc. Bob Smith put Hagerman together, and Clarence Johnson built Marrowstone at the old lighthouse station at the northeast tip of the island.

Historical personnel were the stalwarts in this Columbia River Development Program. Benny Cox developed and ran the Little White Salmon Hatchery with an iron hand. He took no umbridge, but would listen to well-thought-out and tested opinions. As a monthly visitor at Willard – at that time the Western Fish Nutrition Laboratory – he offered many practical pressing questions to be answered. Clyde Adams, our Native American Indian, ran the Spring Creek hatchery most successfully. Clyde said little, but listened well and out-produced most of the other hatcheries. Bernier ran Willard hatchery and was often in our hair at the laboratory urging us to work more on his pressing problems (which we often did). Bruce Kennedy ran the Wind River hatchery and, after he went to the Regional Office in Portland, Don Cairns built up the new Carson hatchery. Both were crafty opponents in either research discussions or especially in the poker sessions upstairs in the lab in the evenings. Roger Burrows was introducing his innovations in fish culture technology, first at Entiat and then later at Abernathy. His lot weighing techniques were adopted nationwide as the best for experimental lot weight measuring. Harlan "Red" Johnson was the experimental biologist at Dorena Dam in Oregon, and then moved to Little White to set up the first hatchery biology control lab for both disease and diet tests.

The first Northwest Fish Culture Conference was convened in Portland, Oregon, by Dr. Perry in 1950. Its purpose was to pool the thoughts of fish nutritionists, fish pathologists and fish culture technologists on what should be done to improve salmon production. Al Kemmerick of the Columbia River Development Program attended since he was the source of most of the funds for the proposals to be developed. Roger Burrows was there, along with Rus Sinnhuber, representing Oregon State University; Tom McKee, the Seafoods Lab at Astoria; Bob Rucker of US Fish and Wildlife Service, for disease problems; and John Halver was invited to present the nutrition problems and to plan new research programs.

The next year, Roger Burrows was elected chairman and he organized a larger meeting inviting many of the fish hatchery managers to Wenatachee. Thus the Northwest Fish Culture Conference was formed and implemented.

More pioneers could be named, but this short list illustrates the type of dedicated personnel who laid the foundations for the current plethora of hatcheries, diet development, nutrition, disease and physiology labs in the Columbia River system today. As new information was disclosed, it was adopted by the state hatchery systems as well. Washington, Oregon, and Idaho have joined with the U.S. Fish and Wildlife Service efforts to improve fish culture in this area of the world. Each has something to contribute – to each unit a mission exists to integrate the knowledge and effort to understand the many parameters which in total make up successful fish husbandry.

CREAM CANS TO STAINLESS STEEL TANKERS

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Abstract

Cream cans to stainless steel tankers is a presentation on the history of Idaho Fish and Game's hatchery system. The presentation will show historic and current photos of hatcheries, old timers doing it the hard way and new technology of today's culturist. Then the results of all our hard work " Happy fisherman."

Presentation

Cream cans to stainless steel tankers is a presentation on the history of Idaho Fish and Game's hatchery system. In the "good old days" hard work and sweat were used to load fish into cream cans on Model T trucks and mule trains for transportation to Idaho waters. Today it is still hard work by dedicated fish culturists that raise fish for sportsman fishing in Idaho, but perhaps less sweat is shed with the development of new technology such as fish pumps and helicopters.

In 1907 Idaho state legislature authorized the construction of Hayspur Hatchery, Idaho's first fish hatchery. Since then 21 hatcheries and six satellite facilities have been constructed by State of Idaho, Idaho Power Company and Army Corps of Engineers. These facilities are operated by 62 permanent staff and a small army of temporary personnel.

The formation of Idaho Department of Fish and Game in 1938 shifted the administration of state hatcheries from the state legislature to the responsibility of the newly formed Fish and Game department.

Fish stocking records from 1913 to present show 25 species and approximately one-half billion fish have been stocked by Idaho hatcheries. Although our current mission statement may differ from the one of 1907, the final objective is the same; create fishing opportunity and happy fisherman. In 1996 4.11 million days of fishing effort was exerted by 486,000 fishermen.

FISH FOR THE FUTURE

G. Wm. Klontz
Technical Services Advisor
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Presentation

In the opinion of many, the runs of hatchery-raised salmon and steelhead in the Columbia River Basin are declining at an alarming rate. So much so that some experts have opined that the demise the these runs will occur within the next 15-20 years. Reasons for this range from an ability to cope with the environment to being just plain inferior to their wild brethren.

In my opinion, the problem is much larger than the experts apparently think. The loss of natural spawning habitat through urbanization, timber harvest, mining, cattle and sheep grazing, and agriculture is a significant factor. The climatic changes in the ocean environment has altered the food supplies for many marine animals. The reservoirs created behind hydroelectric structures have provided havens for predators. The dams themselves have altered the downstream and upstream migration patterns. The hatchery environments have created significant behavior modifications that have reduced the survival potential of the smolts. And, lastly but not leastly, the politics of public and private agencies having some jurisdictional oversight of these fish and the basin, in general, have, in many cases, hindered the reduction of the overall problem.

Given the foregoing, one could think that the population reductions of Pacific salmon and steelhead is a problem unique to the Columbia River Basin. This is far from the case. Virtually all the natural and hatchery-raised runs throughout the Pacific Northwest are affected - some worse than others.

So, what to do? We cannot change the ocean environment - at least economically. We can reclaim some of the lost natural spawning habitat by limiting or restricting the activities contributing to their being lost in the first place. In this case, politics will be the influencing factor. We can remove the offending impoundments, thereby hopefully reducing the predation potential. We can collect the downstream migrants at appropriate collection sites and transport them around the reservoirs and dams.

In my opinion, there is not a single solution to this problem. The groups concerned with making plans and recommendations are being very short-sighted if they think this is so. For example, the breaching of the four dams will not solve one of the major problems associated with downstream migration. For example, the annual reports to BPA by Buettner and Nelson (1989; 1991) provide thought provoking conclusions on the smolt counts entering the Lower Granite Reservoir. According to their data, there have been, over the years, significant unaccountabilities of smolts from the Sawtooth, McCall, and Rapid River hatcheries in Idaho arriving at the Lower Granite Reservoir.

No one, to my knowledge, has addressed reason(s) for this degree of unaccountability. Along the way from the points of release to the Lower Granite Reservoir, there are no dams, no nitrogen supersaturation, no predators to speak of - just free-flowing rivers in their spring run-off condition. Thus, attention should point to something being associated with the pre-smolt period in their respective hatcheries. One could think that perhaps these hatchery fish could not swim competitively in the riverine environment. This seems quite reasonable since these fish have spent upwards of the past 14 months in an environment without too much velocity or turbulence and they were fed several times a day. At the time of smoltification they were released into rivers flowing at spring run-off velocities, turbulences, and clarities. Thus, it is quite reasonable to assume that many of these fish just could not cope with these conditions and became the "unaccounted".

If the foregoing logic is valid, then it further seems reasonable to assume that increasing the water velocities all along the course of the Snake and Columbia Rivers could worsen rather than increase the survival potential.

Perhaps a proposal should be developed and implemented at the Upper Snake River Basin hatcheries to increase the survivability of smolts raised at the Upper Snake River Basin hatcheries. The objective of such a study would be literally to teach the fish to swim during their residence in the hatchery environment. This could occur by making some very inexpensive and non-life-threatening modifications in the hatchery ponds.

Many researchers have considered swimming stamina of hatchery-raised and wild fish a very important criterion for performance in the natural environments (Horak, 1972; Greenland and Thomas, 1972; Green, 1964; Flagg et al, 1983; Besner and Smith, 1983; Black, 1965; Poston, 1975; Houlihan and Laurent, 1987). Evaluation of swimming stamina, in most studies, was accomplished by forcing the fish to swim against high water velocities to the point of exhaustion. The end-point was the maximum velocity that induced exhaustion during swimming periods of 2 to 80 minutes. Although most researchers deduced from their studies that better post-release survival might be correlated with swimming stamina, few studies were conducted to confirm this conclusively. Horak (1972) examined swimming stamina versus post-release survival but was unable under the test conditions used to demonstrate the relationship between stamina and post-release survival. Creswell and Williams (1983) examined the effects of pre-test exercise on swimming endurance. They concluded that hatchery fish should be conditioned to stream velocities at least two days prior to release if survival were to be increased. However, better post-release survivals were recorded following 14 days of pre-release exercise. This effect confirmed the observations of Burrows (1964), who reported increased adult return rates in populations raised for 7 months in circular tanks with high water velocities. Burrows also reported that the fish raised in circular tanks exhibited improved growth rates and increased swimming stamina.

I question the validity of assuming that swimming stamina per se is a realistic criterion for post-release riverine survival, an environment with which free-living populations of fish cope continuously. The majority of testing conditions used to evaluate swimming stamina primarily measured the ability of the fish to tolerate elevated levels of white muscle lactic acid with its attendant decrease in blood pH (Johnston, 1982). The light muscle, used primarily for short-lived burst swimming, functions anaerobically and is quite susceptible to fatigue. The dark muscle, used primarily for sustained swimming activity, functions aerobically and is very resistant to fatigue.

The observations of Burrows support the contention that long-term physical conditioning has merit. There are conclusive data to demonstrate that fish can be conditioned for increased growth performance and sustained swimming capacity. For example, fish required to swim in sustained water velocities of 1.0 - 1.5 body lengths per second exhibited higher growth rates than did their counterparts in still waters (Leon, 1986; Jobling, 1991; East and Magnan, 1987; Davison and Goldspink, 1977; Houlihan and Laurent, 1987; Greer-Walker and Emerson, 1978; Christiansen et al., 1989). There was agreement by all authors that prolonged exercising improved feed conversions and increased the amount of feed required for satiation (Jobling, 1991). More significantly, there were exercise-associated changes in body composition; i.e., significant increases in muscle mass (Davison and Goldspink, 1977), increases in body protein and decreases in lipid (Jobling, 1990; Christianson et al., 1989).

In addition to quantitative changes in proportions of muscle tissue, there were exercise-associated histological changes in the light and dark muscles (Johnston, 1982; Davison and Goldspink, 1977). Others reported associated changes were a decrease in oxygen demand in stressor conditions (Woodward and Smith, 1985) and an increased stamina to high water velocities and turbulences (Burrows, 1964).

The foregoing citations conclude that several weeks of exercise are required to create a significant proportional increase in dark muscle. Perhaps it would be better to condition the fish throughout the majority of their pre-smolt period under controlled hatchery conditions.

To reduce the behavior modification potential the investigative conditions should include irregular feedings and sprinklers providing a visual barrier between the fish and the feeder. Fish in the wild feed irregularly with periods of high expenditure of swimming energy to cope with the water velocity and to avoid predators. Studies conducted under laboratory conditions have demonstrated the efficiency of irregular over regular feedings (Klontz et al., 1991). Fish fed irregularly displayed less interfish aggression (as evidenced by fin nipping). Also,there were less size variations within populations and no negative effects on feed conversions. Intermittent feeding also generated positive effects on growth performance and body condition.

There is little information on the effects of exercise combined with irregular feedings or short periods of starvation. Black (1965), in studies of the effects of short-term exercise and starvation on glycogen metabolism, observed significant decreases in blood glucose levels following two minutes of strenuous swimming by starved fish.

There are no known studies addressing the combined effects of long-term exercise and feeding regimen. Also, there are no known reports of post-release survival following long-term exercise and irregular feeding regimens.

An approach to evaluate the effects of long-term exercise on post-release survival and adult returns should consist of pre- and post-release evaluations. Also, identifiable groups of fish on the exercise and not exercised regimens should be established at each of the involved hatcheries.

In the pre-release portion, ponds - whether they be raceways or circulating ponds - could be configured to provide specified water velocities by altering either the cross-sectional area of the pond (raceways and Burrows ponds) or the angle of water inflow (circular ponds). Raceways could also be configured to provide specified water velocities by inserting two sets of longitudinal panels in the ponds to provide an S-shaped flow. In addition, ponds could be provided with sprinklers to reduce the visibility of the staff at feeding times. Ponds used for the non-exercised (Control) fish could be used unmodified. Prior to release from the hatchery environments, sufficient numbers of fish in both groups - Test and Control - could be tagged for downstream monitoring after release and return as adults some years later.

The pond loadings should be no more than 50% of the maximum allowable population densities. One of the major stress inducers in the hatchery environment is population density. For some reason, in years gone by, it was considered efficient to have densities of 50-75 kg/cubic meter. The result was and is a "swimming fankfurter" because of the fin loss through nipping or a "midnight special" because of the generalized melanosis.

During the pre-smolt period, data to evaluate the following performance parameters should be collected on a regular basis; i.e., biweekly or monthly. I am suggesting the consideration of 15 performance indicators, which are:

1) Growth, which can be measured as a function of changes in length, weight and condition factor. The daily length and weight increases may be affected by the combination of exercise and feeding regimens. The condition factor is considered to be directly related to fitness and should be within a definite range for post-release survival. The exercise and

feeding regimens should affect this parameter. It should be considered as an important response variable for future hatchery practices.

2) Size variation, which is primarily the result of food availability and the individual feeding aggressiveness of the fish. It can be measured as the coefficient of variation for population lengths and weights.

3) Feed conversion ratio, which is not one of the prime considerations of these studies although reports in the literature imply that there will be improved feed conversion ratios with exercise.

4) Specific growth rate, which can be calculated the method developed by Focht (1983). The formula accounts for decreasing age-dependent growth rates and has been shown to be quite useful under hatchery conditions. The formula is:

$$SGR = ((1 + (W_e - W_i) / W_i)^{(1/n)} - 1) * 100$$

Where: SGR = Specific growth rate (%/day)
W_e = Weight (g/fish) at the end of the growth period.
W_i = Weight (g/fish) at the beginning of the growth period
n = Number of days in the growth period
100 = Decimal-removing factor

5) Organosomatic indices, which can be determined using the Goede method described and implemented by Warren (1990). These morphometric, physiological and chemical values can serve to document the physical condition of the fish. These data should contribute to the interagency data bank.

6) Muscle mass and histology, which can be determined on a bi-monthly basis. These evaluations should also be done on recovered post-release hatchery fish and wild fish.

Fish experiencing long-term exercise have been shown to have an increase in muscle mass and alterations in proportions of dark (sustained swimming) and light (burst swimming) muscle (Davison and Goldspink, 1977). There was also an attendant increase in dark muscle fiber diameter with sustained exercise (Johnston, 1982; Davison and Goldspink, 1977).

7) Hematological parameters consisting of hematocrit (% packed cells), hemoglobin (g / 100 ml blood), erythrocyte count (n / mm^3), mean corpuscular volume (nm^3), mean corpuscular hemoglobin (uug), mean corpuscular hemoglobin concentration (%), and serum proteins (g / 100 ml) can be determined using standard methods. These parameters are considered to be invaluable physiological criteria when employed properly for assessing the physiological status of fish.

8) Proximate analysis of whole fish, muscle, and viscera can be determined. This is to evaluate relative changes in lipid and protein levels during the course of the study. It is assumed that lipid contents will be negatively correlated to sustained swimming ability and post-release survival. Protein content is directly correlated with muscle mass, thus exercise should generate increases in protein levels apart from those occurring as growth.

9) Oxygen demand (Standard Metabolic Rate) (SMR), which can be determined using the method described by Klontz et al (1983a). The SMR is an indicator of the ability of fish to respond to stressful situations. Woodward and Smith (1985) noted that exercised fish exhibited a decreased SMR during short-term periods of stress than did their unexercised counterparts.

10) Prevalence of environmental gill disease, which is a frequent clinical manifestation of a chronic stressful situation, also affects the SMR by requiring an increased pO_2 to satisfy the blood oxygen demand (Klontz et al 1985). Thus, the SMR data could be influenced by this condition. Examination can be made by wet mounts of the gill tissues. Quantification can be based on severity using a scale of 1 - 5 (1 = no change; 5 = occlusive interlamellar hyperplasia).

11) Prevalence of latent bacterial infections , particularly *Renibacterium salmoninarum*, which can affect the physiological responses to stressful situations. Examinations for *R. salmoninarum* and other organisms endemic to the study hatcheries can be conducted by the ELISA method.

12) Mortality, which is a response to the inability of the fish to cope with its environment or to the occurrence of a microbial pathogen. Thus, the exercised fish should have a lower cumulative mortality than their unexercised counterparts.

13) Social behavior patterns, which can be measured by the prevalence of fin nipping at times of inventory. Post-release behavior in the wild should be

recorded for comparative purposes. This will require the cooperation of agency field personnel.

14) Feeding behavior of post-release fish, which can be evaluated by examining the stomach contents of recovered post-release hatchery fish and wild fish. The questions to be answered are:

   a. Did the hatchery fish ingest the same foodstuffs as the wild fish?

   b. How rapidly following release did the fish begin to eat?

   c. Is there a relationship between in-hatchery feeding regimen and post-release feeding behavior and food preferences?

15) Recovery of tagged fish released from the study hatcheries, which is the one of the main purposes of these studies. The collected fish should be sampled for the same physical and physiological examinations conducted on the fish in hatchery studies.

In conclusion, the foregoing is but one approach to reducing the downstream migrating smolt loss and increasing the adult returns. To some, it may seem a bit facetious to say that one of the best ways to reduce fish mortality is to teach the little beggars to swim. Also, to some, the list of performance indicators may seem a little excessive and more appropriate to the university laboratory, although, if one thinks about it, they are not excessive and they belong in a hatchery study. Finally, if one thinks the approach has merit and implements it or another like it, I will have been successful in my efforts. And, I am willing to help in any way I can.

Literature Cited

Besner, M. and L.S. Smith, 1983. Modification of swimming mode and stamina in two stocks of coho salmon (*Oncorhynchus kisutch*) by differing levels of long-term continuous exercise. Can. J. Fish. Aquat. Sci. 40:933-939.

Black, E.C. 1965. Combined effect of starvation and severe exercise of glycogen metabolism of rainbow trout (*Salmo gairdneri*). J. Fish. Res. Bd. Canada 23(9):1461-1463

Beuttner, E.W. and V.L. Nelson. 1989. Smolt condition and timing of arrival at Lower Granite Reservoir. Annual Report, 1988. Proj. No. 83-323 B., BPA

Beuttner, E.W. and V.L. Nelson. 1991. Smolt monitoring at the head of Lower Granite Reservoir and Lower Granite Dam. Annual Report, 1991. Proj. No. 83-323 B., BPA

Burrows, R.E. 1964. Effect of fingerling stamina on adult survival. Proc.NW Fish Cult Conf., pp. 54-55, Corvallis, OR.

Christiansen, J.S., E. Ringo and M. Jobling. 1989. Effects of sustained exercise on growth and body composition of first-feeding fry of Arctic charr, *Salvelinus alpinus* L., Aquaculture 79:329-335.

Cresswell, R.C. and R. Williams. 1983. Post-stocking movements and recapture of hatchery-reared rainbow trout released into flowing waters: Effect of prior acclimation to flow. J. Fish Biol. 23:265-276.

Davison, W. and G. Goldspink. 1977. The effect of prolonged exercise on the lateral musculature of brown trout (*Salmo trutta*). J. Exp. Biol. 70:1-12.

East, P. and P. Magnan. 1987. The effect of locomotor activity on the growth of brook charr (*Salvelinus fontinalis*, Mitchell). Can. J. Zool. 65:843-846.

Flagg, T.A., E.F. Prentice, and L.S. Smith. 1983. Swimming stamina and survival following direct seawater entry during parr-smolt transformation of coho salmon. Aquaculture, 32:383-396.

Focht, R. 1983. Trout growth in aquaculture systems: Methods of estimating daily percent weight gain. M.S. Thesis, Fishery Resources, Univ. Idaho. 98 pp.

Green, D.M. 1964. A comparison of stamina of brook trout from wild and domestic parents. Trans. Amer. Fish. Soc. 93:96-100.

Greenland, D.C. and A.E. Thomas. 1972. Swimming speed of fall chinook salmon (*Oncorhynchus tshawytscha*) fry. Trans. Amer. Fish. Soc. 1972(4):696-700.

Greer-Walker, M. and L. Emerson. 1978. Sustained swimming speed and myotomal muscle function in the trout (*Salmo gairdneri*). J. Fish Biol. 13:475-481.

Horak, D.L. 1972. Survival of hatchery-reared rainbow trout (*Salmo gairdneri*) in relation to stamina tunnel ratings. Prog. Fish-Cult. 4:217-220.

Houlihan, D.F. and P. Laurent. 1987. Effects of exercise training on the performance, growth, and protein turnover of rainbow trout (*Salmo gairdneri*). Can. J. Fish. Aquat. Sci. 44:1614-1621.

Jobling, M. 1991. Fulfilling the impossible dream. Fish Farmer. 13(4):52-53.

Johnston, I A. 1982. Physiology of muscle in hatchery-raised fish. Comp. Biochem. Physiol. 73B(1):105-124.

Klontz, G.W., C.M. Herr and T.J. McArthur. 1983. Aquaculture techniques: Preliminary studies on carrying capacities and census-taking in serial reuse ponds. Tech. Comp. Rept. A-075IDA, IWRRI, 44pp.

Klontz, G.W., M.H. Maskill and H. Kaiser. 1991. The effects of reduced continuous versus intermittent feeding of rainbow trout. Prog. Fish-Cult. 53(4):229-235.

Klontz, G.W., B.C. Stewart and D.W. Eib. 1985. Chap. 20: On the etiology and pathophysiology of environmental gill disease in juvenile salmonids. *In* Fish and Shellfish Pathology (A.E. Ellis, Ed.), Academic Press, pp. 199-210.

Leon, K.A. 1986. Effect of exercise on feed consumption, growth, food conversion and stamina of brook trout. Prog. Fish-Cult. 48:43-46.

Poston, H.A. 1975. Influence of dietary protein and energy on swimming stamina, growth and body composition of brown trout. Prog. Fish-Cult. 37:257-261.

Warren, J.W. 1990. Augmented Fish Health Monitoring - Annual Report. BPA. 132 pp.

Woodward, J.J. and L.S. Smith. 1985. Exercise training and the stress response in rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 26:435-447.

HATCHERIES OF THE FUTURE

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Presentation

From all the reports and opinions generated by the experts on the status and future of the salmon and steelhead runs, one could assume that the current hatcheries raising Pacific Salmon and steelhead in the Pacific Northwest are more a detriment than a benefit to preserving the runs. The main concern expressed is the behavior modification factor. These fish during the first 14-16 months of their life are raised in virtually static water systems, in often highly crowded conditions, fed regularly a manufactured diet, and subjected to all manner of physical handling stressors. At the end of their hatchery residence period - in the spring months when the snow melt has raised stream levels and velocities significantly - the smolts leave the hatchery environments and migrate seaward. A significant portion of them do not make it into the marine environment.

Along the migration route there are several environmental factors which affect smolt survival. First, leaving the peace and tranquility of the hatchery environment and entering a raging torrent provides the first impediment. In Idaho, according to IDFG biologists, significant numbers of smolts from the Rapid River, McCall, and Sawtooth hatcheries are lost before they enter the Lower Granite Reservoir - and there are no dams along the way - just highly turbulent, murky water. It has been speculated that these smolts lack the ability to swim. Those which survive the first leg of the journey arrive at the first reservoir probably quite elated at reaching a stretch of quiet water only to find that their feeder - the hatcheryman - is not there to provide them with some food. While in the reservoir trying to figure out which way to go comes the next peril - the predaceous squawfish and walleye pike. Since this is all new, the predators are not regard as perilous. So many get eaten. By now the original number has been reduced by as much as 50% and there may be several more reservoirs to traverse. Finally some make it to the estuary and the fish-eating bird populations. What few are left to pass into the marine environment than face the task of finding food and staying clear of predators -even their own species but a year or so older. But, alas, El Nino and his sister, La Nina, have created water conditions unable to provide sufficient food for the survivors. As a result, after 2-4 years of ocean life, many adults return to their streams of origin in often quite an emaciated shape, which is not conducive to upstream migration and survival to the spawning grounds.

So, what to do? How can we return this dismal scenario to some semblance of normalcy?

First, husbandry practices must be changed to meet the needs of the fish and not those of the administrators in the front office many miles away. Decisions such as how many eggs and/or fish can a facility produce must be made by the resident staff. Pond loadings must be made on the basis of being virtually stressor-free. The practice of trying to raise 10 lbs of fish per cubic foot of water is not doing the fish any favors. And the practice of trying to raise 10 lbs of fish per gpm is also not doing the fish any favors.

The suggested population densities should not exceed 50% of the calculated maxima based upon Piper's Density Index. The pond loading should also be such that the outfall dissolved oxygen is never less that 70% of saturation. This probably means that a given facility probably will produce less numbers of fish than previously. If history is any indicator, fewer numbers of better fish are more likely to return to harvest and spawn than are larger numbers of physiologically compromised fish.

Inventories of ponds should be done so as to minimize the stressor factor. Fish should be off feed for at least 24 hours. Grab samples - at least 5 samples of 20 fish - should be anesthetized and the individually weighed (+/- 0.01 g) and measured (+/- 1.0 mm). Calculations should include the mean, median, range and mid-range of values, the standard deviation, the coefficient of variation, condition factor and the specific growth rate.

Feeding should be done on an irregular basis - skipping a day now and again. In fact, not feeding on week-ends has been quite good. This method reduces the habit-forming potential.

Second, pond design must change so as to provide the fish with a moderate degree of exercise. According to the Norwegian workers, the ideal water for salmonids should be between 1.0 and 1.5 body lengths per second. To achieve this, raceways can be modified inexpensively with plywood groins to create a zig-zag water flow. The water inflow to rectangular circulating ponds; e.g., the Burrows pond, the Rathbun pond, the Richardson D-end pond, and circular ponds can be modified to provide the proper water velocities.

Third, ponds should be fitted with a sprinkler system so that the fish believe they are living in a perpetual rainstorm. The food comes from somewhere above.

Fourth, transferring fish from pond to pond or to transporters should be done with the fish in water not in nets.

Fifth, record-keeping must be improved and standardized so that tracking populations through several year classes is possible. Daily mortalities, treatments, water temperatures and dissolved oxygens, feed conversion ratios, specific growth rates, and special activities must be included.

Now for the grand finale: What should a hatchery of the future be? First, it should be built on a hill-side with gravity flow water. Flat land hatcheries do not provide sufficient gravity to move water quickly. Second, ponds should be of the single-pass rectangular circulating types with supplemental aeration; e.g. the Richardson D-end pond. This configuration provides common walls and is no more space consuming than a raceway system. Raceways, especially multiple-pass raceways, should be considered historical. In my opinion such systems throughout the years have been a major causal factor in episodes of noninfectious and infectious disease. Plumbing should be such that fish can be moved between ponds by swimming through a pipe using a movable screen stimulus. It also should be such that smolts and adults can be moved to and from transporters by swimming through a pipe. Third, feeding should be done with mechanical feeders set for irregular intervals. Fourth, pond populations should be monitored by yet-to-be-designed electronic instrumentation. All mathematical calculations should be done using computerized programs designed by a systems analysis engineer - the "new kid on the block". And finally, resident staff must live on site. Off-site staff relying on alarm systems is not not practical.

And, that about does it. But, until this type of facility is a reality, we must use what we have to its best advantage.

Now a message for the "old timers" - Use these youngsters coming out of university programs. Their primary function is to make you look like a million dollars. Please do not try to make them over into your image. Let them "bloom and flower". They should have received state-of-the-art methods of intensive fish culture during their university years you might be surprised what can be learned from them. These folks are the future to solving this whole mess we have allowed to be created.

Session II:

Monitoring and Evaluation

Session Chair:

Ed Crateau
USFWS
Lower Snake Compensation Plan Office

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POSTRELEASE RECOVERIES OF HAND FED VERSUS DEMAND FED SEA-RUN CUTTHROAT TROUT, AND POSTRELEASE SURVIVALS OF SEA-RUN CUTTHROAT REARED IN A POND FOR VARIOUS DURATIONS

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Abstract

An experiment that compared the smolt-to-adult survival of Cowlitz Hatchery sea-run cutthroat that were hand-fed versus demand fed showed that for three years of release demand fed fish outperformed hand-fed fish by an average of 9.5%, not statistically different.

An experiment comparing the smolt-to-adult survival of hatchery sea-run cutthroat that were placed in a rearing pond for months prior to release versus one month prior to release showed that an average of 20% more fish returned which had been reared in the pond for months versus one month prior to release.

Hand vs Demand Feeding

At salmonid hatcheries, two common methods of delivering feed to fish are hand-feeding and demand feeders. Advocates of hand-feeding like monitoring fish health and vigor while feeding. Users of demand feeders often claim savings in feed and labor costs (Statler 1982; Kindschi 1984; Tipping et al. 1986; Alanara 1992; Aloisi 1994). Fish behaviors differ in the two feeding methods; hand-fed fish are attracted to the person delivering the feed while fish with demand feeders often some fright response to people moving along the rearing vessel. This behavior difference might influence post-release survivals. However, no literature was found comparing the post-release survival of fish reared on the two methods or any other feed delivery system. This experiment was conducted to compare the post-release survival of fish reared by hand-feeding compare to those on demand feeders.

Methods

At the Cowlitz Trout Hatchery in October 1996, 1997, and 1998, sea-run cutthroat trout juveniles weighing about 40-50 g each were marked and randomly assigned to one of two raceways, each containing about 25,000 fish. Thereafter, fish in one raceway were fed ad libitum with dry feed using four Babington demand feeders per raceway. Fish in the second raceway were fed by hand three to four times per day.

The raceways were 6.1 x 30.3 x 0.9 m with a water flow of about 74 L/s of re-used well water mixed with river water. The raceways also had six strands of wire placed lengthwise above the raceways to deter avian predators.

The fish were marked with a left ventral fin-clip in combination with a magnetic wire tag placed in the left or right cheek in 1996 and 1998. In 1997, the fish were marked with only a wire tag in the left or right cheek.

Both groups were released concurrently in late April of each year. At release, about 300 smolts from each group were measured for fork length (cm) and 50 fish were weighed (g) so condition factor ($K=[10^2 \text{weight,g}]/[\text{length,cm}]^3$) could be determined. Several hundred fish were sampled for the presence of a wire tag with a wand detector (Northwest Marine Technology, Shaw Island, Washington). The appropriate tag retention rate (range 71-90%) was applied to the number of fish released to determine the number of tagged fish released in each group. The release site was about 109 km upstream on the Columbia River, 68 km up the Cowlitz River, and 1 km up Blue Creek; the hatchery rack was about 0.6 km above the release site.

Recoveries of tagged adult cutthroat trout were obtained with occasional creel checks of recreational anglers from August through October from 1996 through 1999. In addition, all cutthroat trout entering the Cowlitz Trout Hatchery in November through January were examined for tags. A ventral fin of fish returning to the hatchery was excised so they would not be counted in a subsequent year or the fish were moved to a non-anadromous water.

Chi-square ($\underline{P}=0.05$) was used to compare the number of fish returned from the two groups of fish. Student's t-test ($\underline{P}=0.05$) was used to test for differences in length and condition factor of smolts at release.

Results

At release, a 0.3 cm length difference for the 1996 release was significantly greater for demand than hand-fed fish ($t= 3.73$, $p<0.05$) and a 0.7 cm length difference for the 1997 release of demand-fed fish was significantly greater than hand-fed fish ($t=5.50$, $p<0.05$) (Table 1). The 1998 release was statistically similar. However, prior work has shown that the lengths at release for all three years observed herein would be biologically similar for Cowlitz Hatchery sea-run cutthroat (Tipping 1986; Tipping and Blankenship 1993).

A total of 1,004 marked adult fish were recovered; the hatchery rack accounted for 96.0% while 4.0% were recovered in the sport fishery. Final recoveries for the 1998 release will occur this winter but they are not expected to change overall results. Recoveries of the 1998 release were two to three times greater than the 1996 and 1997 releases.

For the 1996 release, adult recoveries of demand-fed fish were 38% greater than hand-fed fish, a significant difference ($X^2=4.34$, $p<0.05$). For the 1997 release, recoveries of demand-fed fish outperformed hand-fed fish by 24% but were not significantly different. For the 1998 release, hand-fed fish outperformed demand-fed fish by 2%, statistically similar. For all releases combined, 0.92% of demand-fed fish were recovered versus 0.84% for hand-fed fish, a 9.5% increase, which was not significantly different.

Discussion

Results from this experiment were not compelling: demand-fed fish had an overall increase in adult returns of about 10% but only statistically showed benefit in one of three years of release. Although a 10% increase would certainly be a welcome increase to adult return rates, other feeding methods need to be developed that might increase adult survivals (Wiley et al. 1993; Maynard et al. 1995). Conversely, unless a better feeding method that increases survival is developed, hand or demand feeding appear to produce fish with similar survivals.

Table 1. Length, weight, condition factor and adult returns of hand and demand fed sea-run cutthroat.

Release year	1996		1997		1998		Total	
	Hand	Demand	Hand	Demand	Hand	Demand	Hand	
Demand								
Mean Length (cm)	21.9	22.2	22.3	23.0	24.3	24.4		
Mean K	1.09	1.08	1.05	1.07	1.11	1.13		
N=	300	300	304	304	300	300		
No. tagged fish	17,452	18,637	19,386	17,973	21,089	19,862	57,927	56,472
Adult Returns								
First year	67	98	106	130	287	264		
Second year	3	5	24	20	NA	NA		
Total	70	103	130	150			487	517
Percent	0.40	0.55	0.67	0.83	1.36	1.33	0.84	0.92

Pond Duration Study

A common rearing practice at many salmonid hatcheries is to place juvenile fish from concrete raceways into large rearing ponds in February or March prior to spring release. Ponds are thought to improve the quality of fish by exposing them to a more natural environment before liberation (Piper et al. 1982; Maynard et al. 1995). Tipping (1998) reported that sea-run cutthroat trout reared in a pond had 160% of the adult survival of fish produced from concrete raceways. However, it is not known if extended duration of pond exposure increases post-release survival. This experiment was conducted to determine if sea-run cutthroat trout placed in a pond for a month prior to release have the same survival of those reared for a longer time in a pond.

Methods

At the Cowlitz Trout Hatchery in October 1996, 1997, and 1998, sea-run cutthroat trout juveniles weighing about 40-50 g each were marked and randomly assigned to one of two raceways, each containing about 20,000 fish. The fish were marked with a right ventral fin-clip in combination with a magnetic wire tag placed in the left or right cheek in 1996 and 1998. In 1997, the fish were marked with a wire tag in the snout or the nape of the neck.

The concrete raceways were 6.1 x 30.3 x 0.9 m with a water flow of about 74 L/s of re-used well water mixed with river water. Fish were fed ad libitum with dry feed using four Babington demand feeders per raceway. The raceways also had six strands of wire placed lengthwise above the raceways to deter avian predators.

One raceway of fish was moved to a gravel/earth bottom rearing pond in October 1995 at 28 g, December 1996 at 60 g and January 1998 at 90 g for the three release years, respectively. The second raceway of fish was placed in the pond in March at about 83 g in 1996, 105 g in 1997, and 125 g in 1998. In addition to tagged cutthroat, untagged cutthroat and steelhead were also placed in the pond in October to January. About 114,000 cutthroat and 162,000 steelhead were released from the pond in 1996 (22,600 kg), 120,000 cutthroat and 117,000 steelhead in 1997 (19,300 kg), and 80,000 cutthroat and 44,000 steelhead in 1998 (17,800 kg).

For the 1996 release, rearing pond dimensions were 440 x 50 x 2 m, thereafter reduced to 280 x 50 x 2 m for the 1997 and 1998 releases. Pond inflow was about 227 L/s re-used well water mixed with river water. Fish were fed ad libitum with eight Babington demand feeders in 1996 and six feeders in 1997 and 1998 stationed around the pond. The pond was equipped anti-predator exclusion fencing on the ground, an electrical fence, overhead wires, plus U.S. Department of Agriculture personnel were present to haze predators at the hatchery.

Both groups were released concurrently from the pond in late April to early May. At release, about 300 smolts from each group were measured for fork length (cm) and 50 fish were weighed (g) so condition factor ($K=[10^2\text{weight,g}]/[\text{length,cm}]^3$) could be determined. Just before fish were moved from the raceway to the rearing pond, several hundred fish were sampled for the presence of a wire tag with a wand detector (Northwest Marine Technology, Shaw Island, Washington). The appropriate tag retention rate (range 78-89%) was applied to the number of fish released to determine the number of tagged fish released in each group. The release site was about 109 km upstream on the Columbia River, 68 km up the Cowlitz River, and 1 km up Blue Creek; the hatchery rack was about 0.6 km above the release site.

Recoveries of tagged adult cutthroat trout were obtained with occasional creel checks of recreational anglers from August through October from 1996 through 1999. In addition, all cutthroat trout entering the Cowlitz Trout Hatchery in November through January were examined for tags. A ventral fin of fish returning to the hatchery was excised so they would not be counted in a subsequent year.

Chi-square (P=0.05) was used to compare the number of fish returned from the two groups of fish. Student's t-test (P=0.05) was used to test for differences in length and condition factor of smolts at release.

Results

At release, lengths of both groups of fish were similar while earlier ponded fish tended to have slightly greater condition factors (Table 2). A total of 2,392 adult fish from this experiment were recovered; the hatchery rack accounted for 98.7% while only 1.3% were recovered in the sport fishery. Recoveries of the 1998 release were three to nine times greater than the 1996 and 1997 releases.

For the 1996 release, adult recoveries of the October ponded fish were 11% greater than March ponded fish, statistically similar. For the 1997 release, recoveries of the December ponded fish outperformed the March ponded fish by 44% (X^2=15.38, $p<0.005$). For the 1998 release, recoveries of January ponded fish were 7% greater than March ponded fish, statistically similar. For all releases combined, 2.4% of early ponded fish were recovered versus 2.0% for March ponded fish, a 20% increase which was significantly different (X^2=14.69, $p<0.005$).

Table 2. Length, K-factor, number of tagged fish released and adult returns as part of a pond rearing duration study.

Year	1996		1997		1998	
Month Ponded	October	March	December	March	January	March
Mean length (cm)	21.6	21.9	22.5	22.4	24.8	24.8
Mean K-factor	0.93	0.90	1.01	0.98	1.02	1.00
N=	300	300	296	296	300	300
No. marked fish released	17,905	14,602	19,818	20,281	19,797	16,582
Adult Returns						
First year	86	63	254	182	992	775
Second year	5	4	20	13	NA	NA
Total	91	67	274	195		
Percent	0.51	0.46	1.38	0.96	5.01	4.67

Discussion

Results from this experiment indicate that longer exposure times to semi-natural rearing ponds are generally better for post-release survival than short exposures. However, results were statistically significant only for the 1997 release and when all releases were combined. Unfortunately, results did not show an increasing survival trend as pond rearing time increased; the October group (1996) had only an 11% improvement compared to a 44% improvement for the December group (1997). Overall, this study suggests that hatchery managers should move fish from raceways to ponds early if possible.

Also, recoveries of pond-reared sea-run cutthroat trout in this study averaged 2.2% while those from concrete raceways for the hand versus demand feeding study was 0.86%, a ratio of 2.6:1. This is considerably greater than that reported by Tipping (1998) with an improvement of 1.6:1 for a previous study comparing survivals of fish reared in a raceway versus a rearing pond.

References

Alanara, A. 1992. Demand feeding as a self-regulating feeding system for rainbow trout in net-pens. Aquaculture 108:347-356.

Aloisi, D. B. 1994. Growth of hatchery-reared lake trout fed by demand feeders. Progressive Fish-Culturist 56:40-43.

Kindschi, G. A. 1984. Notes on two feed types and methods for steelhead trout production. Progressive Fish-Culturist 46:44-47.

Maynard, D. J., T. A. Flagg, and C.V.W. Mahnken. 1995. A review of seminatural culture strategies for enhancing the postrelease survival of anadromous salmonids. American Fisheries Society Symposium 15: 307-314.

Piper, R. G. , I. B. McElwain, L.E. Orme, J. P. McCraren, L.G. Fowler, and J. R. Leonard. 1982. Fish Hatchery Management. U.S. Fish and Wildlife Service, Washington, D.C.

Statler, D. P. 1982. Use of self-feeders for rearing steelhead trout at Dworshak National Fish Hatchery. Progressive Fish-Culturist 44:195.

Tipping, J. 1986. Effect of release size on return rates of hatchery sea-run cutthroat trout. The Progressive Fish-Culturist 48:195-197.

Tipping, J. M. 1998. Return rates of hatchery-produced sea-run cutthroat trout reared in a pond versus a standard or baffled raceway. Progressive Fish-Culturist 60:109-113.

Tipping, J. M. and H. L. Blankenship. 1993. Effect of condition factor at release on smolt-to-adult survival of hatchery sea-run cutthroat trout. The Progressive Fish-Culturist 55:184-186.

Tipping, J. M., R. L. Rathvon and S. T. Moore. 1986. Use of demand feeders on large steelhead rearing ponds. Progressive Fish-Culturist 48:303-304.

Wiley, R. W., R. A. Whaley, J. B. Satake and M. Fowden. 1993. An evaluation of the potential for training trout in hatcheries to increase poststocking survival in streams. North American Journal of Fisheries Management 13:171-177.

THE EFFECTS OF GROWTH RATE AND A LOW FAT DIET ON THE INCIDENCE OF SEXUAL MATURATION IN 1$^+$ AGE MALE SPRING CHINOOK SALMON

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Abstract

The purpose of our experiment was to determine the effects of growth rate and a low fat diet on the incidence of early sexual maturation in male spring chinook salmon (Oncorhynchus tshawytscha). Fish (0.5 g initial weight) were fed a practical low fat diet (7% fat, 54% protein, 19.7 KJ/g) at six feeding levels (100, 88, 76, 64, 52, or 40% of satiation) from February 1998 until July 1999. A commercial diet (BioOregon-grower: 21.8% fat, 49.9% protein, 22.1 KJ/g) was also fed at the 64% level. All diets were fed in duplicate (700 fish/tank). Fish were sampled at ca. monthly intervals to measure growth, proximate composition and state of sexual maturity. Fish weights at the end of the experiment were, respectively 336, 304, 286, 241, 203, 161 and 258g for the 100-40% ration groups and the commercial feed. Maturing males were significantly larger than nonmaturing males and females, which were similar in all treatments, from March 1999 until the end of the experiment. Whole body fat levels in fish fed the low fat diet at all feeding levels did not differ and remained between 2.5 and 5% from the start of the experiment until September 1998. Body fat levels then increased in these groups. Fish fed the commercial feed had fat levels which increased from first feeding, reached 8% in September 1998, and then continued to increase until May 1999. Maturing males in all treatments had significantly higher fat levels than nonmaturing males or females from January 1999 until the termination of the experiment in July 1999. The incidence of maturing males ranged from 66 to 93% and was significantly affected by feeding level. The relationship between feeding level and maturation, which was lowest in the 40% feeding level fish, highest in fish fed at the 76% level and lower again in fish fed at the 100% level was best described by a quadratic equation. Comparison of data for fish fed the commercial and experimental feeds indicates that body fat level had no effect on the incidence of maturation. Our next study will examine the effects of much lower growth rates (<100 g at 1$^+$) on male maturation.

INCREASED REARING DENSITIES IN HATCHERIES CAN INCREASE RUNS OF COLUMBIA RIVER SPRING CHINOOK SALMON

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Abstract

In 1988, Bonneville Power Administration funded a project at Willamette Hatchery to test the feasibility of using increased rearing densities in existing hatcheries to augment the runs of chinook salmon in the Columbia River Basin. Oxygen supplementation was used to permit increased rearing densities of juvenile chinook salmon without risking the production from poor water quality. Also included in the test were a series of raceways using a new design that incorporated a series of baffles to effect an automatic cleaning of the raceways (Boerson and Westers 1986).

At that time, a series of questions were proposed that the experiment was to answer:

1) Could increased rearing densities in a surface water hatchery result in increased production of adult chinook salmon?
2) Could the baffled raceways be used for rearing increased densities of fish while minimizing the time necessary for cleaning the raceways?
3) Will ammonia concentrations limit production from raceways with increased rearing densities?
4) Does oxygen provide cost-effective benefits for the high-density rearing of chinook salmon.

The experiment required a series of seven experimental raceways of different densities and conformations (Table 1). These experimental raceways were duplicated to account for possible raceway effects. Approximately 30,000 fish from each raceway were marked with adipose-fin clips and coded-wire tags. The fish were reared at Willamette Hatchery and hauled to the Willamette River below Dexter Dam in late February or March for release as yearlings. This procedure was repeated for four years, from 1991 to 1994.

As the marked fish were recaptured in various fisheries, the heads were taken, coded-wire tags removed and decoded, and the data was entered into the PSMFC data base for coded-wire tagged fish. Marked fish entering into the Willamette River Basin were recovered at Dexter Fish Ladder, Willamette Hatchery at spawning, or McKenzie Hatchery at spawning. Snouts were removed and sent to the Clackamas Tag Recovery Station for tag recovery and decoding. Despite the complexities of the design, the experiment was completed with only minor problems. One of the worst of these was that El Nino conditions occurred throughout the time of the releases. In spite of the lowered yields, we could make some definite conclusions:

1) Increased rearing densities in a surface water hatchery can result in increased production of adult chinook salmon (Figure 1). Numbers of adults salmon recovered from rearing densities three times that normally used at Willamette Hatchery showed significantly more spring chinook salmon recovered than numbers from control raceways reared at normal densities, either with or without oxygen. However, the efficiency of rearing at high densities was not as good as with normal rearing densities. Percent returns (the number of adults returning per hundred juveniles released) were inversely related to rearing density. This result has been demonstrated in a number of other studies (Ewing and Ewing 1995).

2) Baffled raceways produced smolts with very poor survival. The reason for the poor survival is unknown, although it was found that fish in these raceways had higher metabolic rates than fish reared under comparable densities or loads (kg fish/gallon per minute flow).

3) Ammonia was not a limiting factor at increased densities. As ammonium ion concentrations increased in response to increased density, pH decreased from carbon dioxide excreted. The decrease in pH suppressed the toxic gas, NH_3*, in favor of the nontoxic ion,* NH_4^+*. This decrease in pH occurred because the surface water supply to Willamette Hatchery is low in carbonate ions and consequently low in buffering capacity.*

4) Cost benefit ratios have not yet been calculated for the increased numbers of spring chinook salmon resulting from increased densities. However, several modifications which became available after the experiment was initiated may serve to bring costs down in future rearing scenarios. One is the availability of oxygen generators which are very cost effective for long-term rearing. A second factor is the programming of oxygen use so that high density raceways could have oxygen delivered only when the oxygen demands become high in late stages of rearing.

In conclusion, the use of oxygen supplementation for rearing increased densities of spring chinook salmon has demonstrated that the number of fish returning to the facility can be increased with minor modifications to existing raceways. This should provide a means for increasing production without the huge capital expense of building new raceways.

References

Boerson, G., and H. Westers. 1986. Waste solid control in raceways. Progressive Fish-Culturist 48:151-154.

Ewing, R. D. and S. K. Ewing. 1995. Review of the effects of rearing density on survival to adulthood for Pacific salmon. Progressive Fish-Culturist 57:1-25.

Table 1. Characteristics of experimental ponds at Willamette Hatchery.

Group Designation	Characteristics
A	Normal density, no oxygen supplementation
B	Half density, no oxygen supplementation
C	Normal density, oxygen supplementation
D	Triple density, oxygen supplementation
E	Michigan system, first pass, oxygen added
F	Michigan system, second pass, oxygen added
G	Michigan system, third pass, oxygen added

Group	Number of fish	Final kg	Inflow Lpm	Load kg/Lpm	Pond volume m_3	Density kg/m_3
A	36,000	1,633	1895	0.86	104.8	15.58
B	18,000	817	1895	0.43	104.8	7.80
C	36,00	1,633	1895	0.86	104.8	15.58
D	108,000	4,899	1895	2.58	104.8	46.75
E	54,000	2,449	2843	0.86	52.4	46.75
F	54,000	2,449	2843	0.86	52.4	46.75
G	54,000	2,449	2843	0.86	52.4	46.75

Figure 1: Average Number of Returning Adults, 1991 - 94 Releases

note: insert hard copy of figure 1 here

MONITORING, EVALUATION AND MANAGEMENT: AN ESA CONNECTION

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Abstract

Snake River sockeye, spring/summer and fall chinook salmon, steelhead and bull trout have been listed under the Federal Endangered Species Act (ESA) to protect and recover those populations from perilously low levels. The ESA, while encumbered with process and paperwork, retains as its central theme a reestablishment of healthy, self-sustaining populations of fish and wildlife within the U.S. For most fish populations, significant changes in their habitat and/or their management must occur before progress toward stable healthy populations can begin.

Understandably, management agencies faced with implementing change must ensure that actions taken are biologically sound and supportable, or at least, that actions have a reasonable chance of reducing negative effects of a condition on the listed species. Unfortunately, agencies such as Washington Department of Fish and Wildlife (WDFW) and federal wildlife management agencies are frequently faced with making decisions about the management of listed species without all the data and knowledge they need. Within the Snake River basin however, the presence of a Monitoring and Evaluation (M&E) study group associated with the Lower Snake River Compensation Plan (LSRCP) hatchery mitigation program has allowed WDFW to respond to the ESA management challenge in a timely fashion.

Background

During the 1970's the states of Oregon, Washington and Idaho, and the U.S. Fish and Wildlife Service negotiated with other federal agencies such as the Corps of Engineers (COE) to mitigate for adult fish losses to anadromous populations caused by construction of the four lower Snake River power dams. The Lower Snake River Compensation Plan (U.S. Army Corps of Engineers 1975) was the result of those negotiations. Hatchery production was considered the most efficient means to replace lost resources, and in Washington, Lyons Ferry Hatchery (LFH) on the Snake River (RM 58) was constructed and the Tucannon Hatchery (RM 36) renovated as the core of the mitigation program (Fig. 1). Washington's anadromous portion of the program was to mitigate for 18,300 fall Chinook, 1,152 spring Chinook, and 4,656 summer steelhead. Additionally, 87,000 pounds of rainbow trout were to be reared to provide resident fish angling opportunity in Washington and Idaho. The Tucannon River is a major Snake River tributary in Washington which receives LSRCP spring chinook salmon, summer steelhead and rainbow trout mitigation, and will be the focus of this discussion.

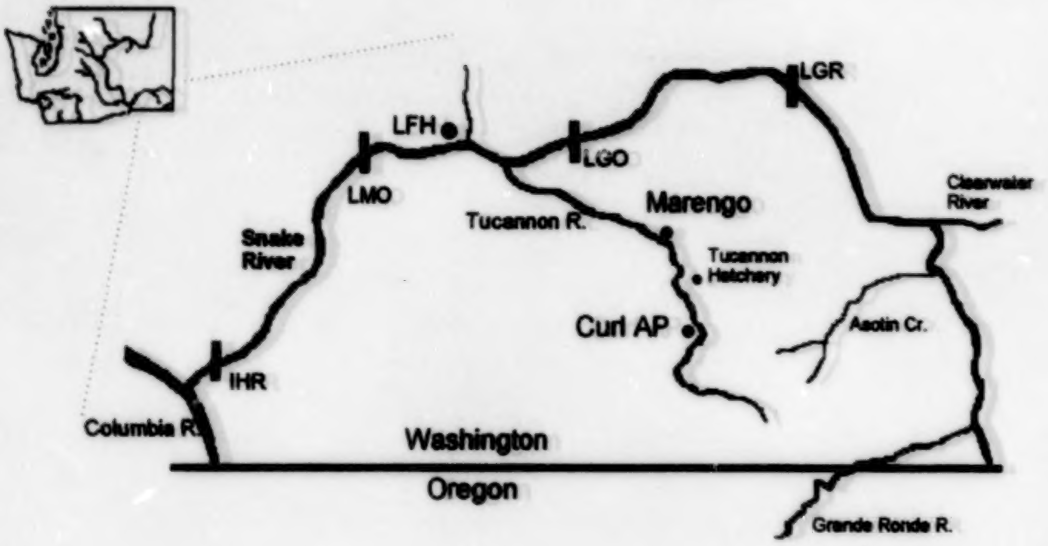

Figure 1.

At the time of the 1991 and 1992 listings of Snake River sockeye and spring/summer chinook under ESA, WDFW was annually releasing 160,000 steelhead into the Tucannon River, the majority of which were acclimated in Curl Lake (RM 41) Acclimation Pond (AP) on the Tucannon River prior to release. Coded wire tag (CWT) studies demonstrated that releases were marginally successful, but still less than the LSRCP goal. WDFW wanted to maximize smolt survival, emigration success, and adult return to meet mitigation goals in an efficient manner.

A 1991-93 M&E study showed that up to 66% of juvenile fish in the AP were not fully smolted, and that 10.3% - 17.7% residualized (failed to migrate) in-river (Schuck et al. 1994). Furthermore, juvenile steelhead which residualized in the river, closely resembled juvenile steelhead which failed to exit the acclimation pond during a six-week volitional emigration period (non migrants). Also, a comparison of adult returns from the 1991-1993 AP released steelhead, to adults returning from direct releases adjacent to Curl Lake AP for the same years, showed that the direct released fish returned at a much greater rate (Schuck et al. 1995). These data caused managers to question acclimation pond use as an effective management tool.

To fully assess acclimated vs. direct released fish performance, M&E staff began a new study in 1994. The study would; 1) determine why the Curl Lake AP release was not performing as effectively as other LSRCP steelhead releases in Washington, 2) try and characterize what constituted a successful smolt using new tag technology, 3) determine if unsuccessful (non migrating) fish could be separated from migrants using the acclimation pond, 4) help identify ways to minimize the potential effects (residualism, predation, competition) of hatchery steelhead releases on wild juvenile salmonids, and 5) determine whether non acclimated direct releases of steelhead near Curl Lake AP and further down-river could survive equally or better than acclimated releases. Results from the 1994-1997 study are summarized here.

Methods

Passive integrated transponder (PIT) tags and CWTs were used to characterize successful migrants. PIT tags represented new technology in 1994 that allowed individual fish to be accounted for after their release. Pre-release or at-release data for each fish could then be ascribed to successful or unsuccessful fish. A study fish was considered to be successful if it was detected downstream of its release point at one of the Snake or Columbia River PIT tag detector dams. Adult survival success (measured as smolt to adult survival (SAR) percentage) was calculated from CWT returns to the Snake basin fisheries, hatchery recovery and escapement as estimated through spawning surveys.

Study groups received a CWT and fin clip 8-9 weeks before being placed in Curl Lake AP, and up to three months before being released directly to the river. All tag groups were held in raceways at LFH for at least 14 days prior to release or transfer, and tag retention determined. CWT tagged and untagged fish within Curl Lake AP contributed to all PIT tag groups. All direct stream releases were 100% CWT, therefore no untagged fish could be PIT tagged for those study groups.

Pond emigrants and juvenile steelhead which failed to exit the acclimation pond, (behaviors which had been observed in the 1991-93 study) were PIT tagged from Curl Lake AP in April and May of the 1994-1997 migration years. Three groups of approximately 115 migrant fish (fish trapped as they left the pond voluntarily) were PIT tagged over a six-week migration period. Fish were netted, anesthetized with MS-222, tagged, weighed, measured, classified (smolt, transitional smolt, parr or precocious male), allowed to recover and then immediately released. The non migrant group consisted of fish which failed to leave the pond after the six-week voluntary emigration period. Three hundred-fifty fish were netted from the pond, PIT tagged in an identical fashion to migrant fish and released into the Tucannon River at the outlet of Curl Lake AP.

PIT tags were detected at down-river dams fitted with PIT tag detection equipment. Unique detections of PIT tags were used to determine success. Multiple detections of a single tag at one or different dams were not counted. Length, weight, condition factor and classification for each detected fish were from date of tagging, not date of detection. Data summaries therefore represent what a fish "looked like" while still in hand at time of release. In addition to Curl Lake AP tag groups, releases of non acclimated steelhead from LFH occurred at LFH and at Marengo (RM 21) on the Tucannon River (Fig. 1) during the last three years of the study.

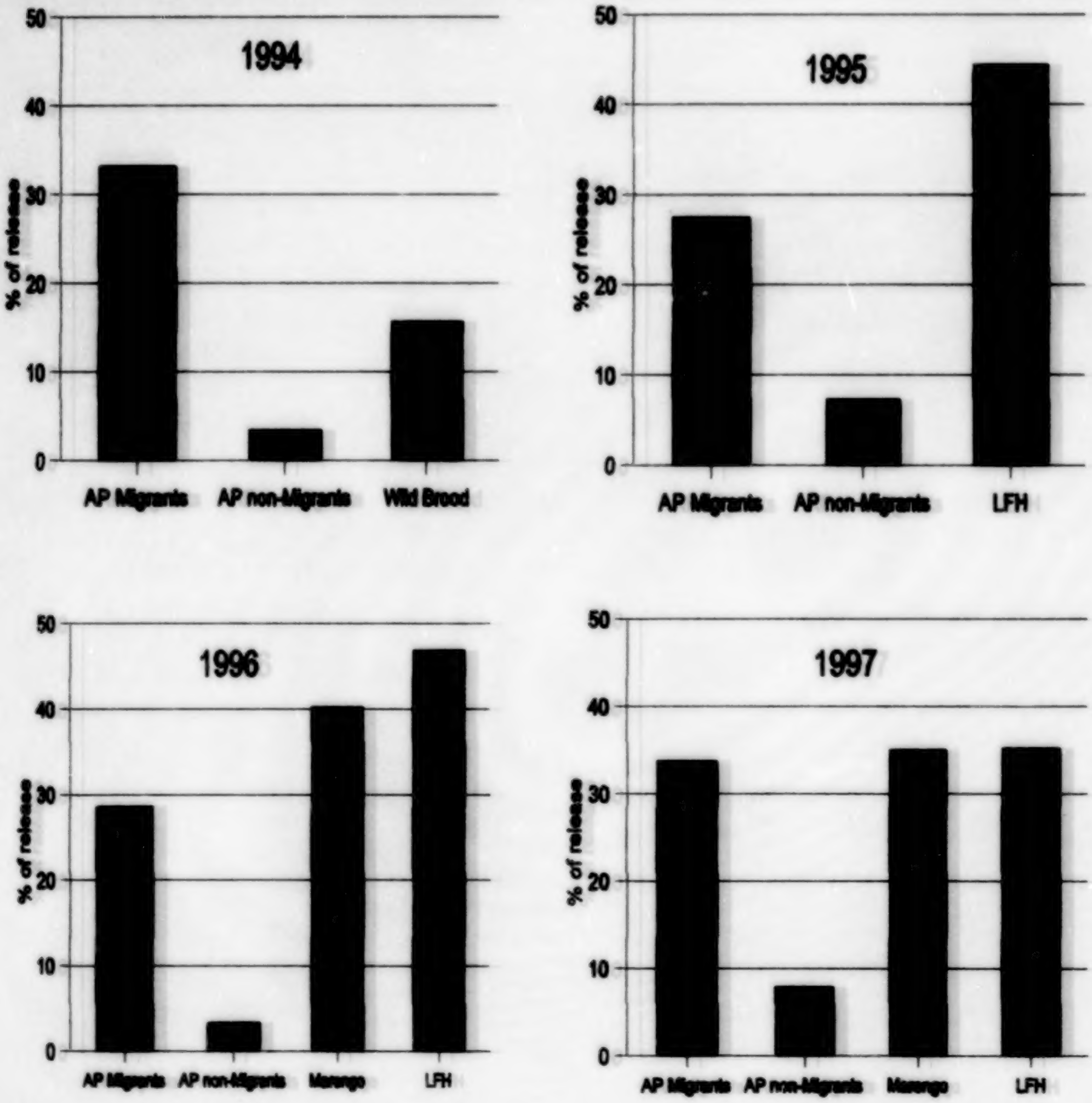

Figure 2. PIT tag detections at Snake and Columbia River dams for Acclimation Pond (AP) and direct releases into the Tucannon River and from LFH, 1994-1997.

Results

There was a 10-fold difference in detections between the AP migrants, and AP non migrants PIT tagged in 1994 (Fig. 2). A release of hatchery reared wild origin Tucannon River steelhead were detected intermediately to the other groups, but this release was not repeated for the duration of the study. Rather, during 1995 a release from Lyons Ferry Hatchery was substituted as a control to which other releases could be compared. Once again a significant ($P<0.001$) difference in detections between AP migrants and AP non migrants was observed, although not to the extent documented in 1994. Interestingly, detections of the LFH-released group were statistically greater than for the migrant group, and far exceeded detected fish from the non migrants (Fig. 2). Because of increasing concern about the effect of any residual hatchery steelhead on a wild spring chinook, the study was modified in 1996 to include a direct release of steelhead near Marengo (Fig. 1). This area of the river is seldom utilized by spring chinook salmon for spawning and rearing, and results from the earlier study strongly indicated that direct releases into the river at Marengo had been successful in returning adults for the program. Further, direct releases of steelhead at or below Marengo were considered an acceptable alternative to acclimation and retention of potentially residual steelhead by NMFS in their Biological Opinion. Also, WDFW desired to repeat releases conducted in the 1991-93 study, and assess direct releases into habitats below most natural salmon/steelhead production as an alternative to acclimation. Once again, 1996 detections of AP migrant fish far exceeded detections of AP non migrant fish (Fig 2). Detections of fish released from LFH were similar to that observed in 1995, greater than either AP group. Interestingly, detections of fish released at Marengo nearly equaled the LFH group and were significantly greater than the AP migrant group ($0.001<P<0.005$, $\propto = 0.05$). Results from the 1997 migration year were nearly identical to the previous three years for the AP groups: detections of PIT tagged migrant steelhead were significantly greater than non migrants. However, there was no statistical difference between detection of AP migrants and releases from LFH and at Marengo in 1997 ($0.90<P<0.75$, $\propto = 0.05$).

Further results from the study provided a characterization of successful out migrants that was consistent for the four years. Those results showed:

1. Successful fish (regardless of the group) were longer, leaner and more smolted than unsuccessful fish, or the pond average just prior to release (Average successful smolt = 3.8-4.0 fpp; 224 mm; K=0.95).

2. No parr or precocious males were ever detected at downstream dams during the study.

3. During the study, 5-14% of the pond's population did not emigrate from the pond, and only 7-9% of AP non migrants were classified as smolts. It was concluded that pond retained smolts would have out migrated if given a chance, based on the small number of PIT tag detections for AP non migrants groups in each year of the study. These fish represented the cost of operating the pond to retain potentially residual juvenile steelhead.

4. Retaining non migrants in the pond decreased the incidence of residuals' in-river (Viola and Schuck 1995).

5. Smolt to adult return rates for downstream releases were consistently higher than for pond releases (data from 1994-97 study is incomplete).
6. There appears to be a direct relationship between release location and survival success.

Discussion

Results from the four years of PIT tagging provided significant insight to the behavior of hatchery steelhead releases in the Tucannon River. In four of 4 years, AP migrants were more successful than non migrants. Work conducted simultaneously with the tagging study by Viola and Schuck (1995) concluded that retaining non migrants in the AP significantly reduced the number of residual steelhead in the river. This result was fully in line with the NMFS desire to reduce the potential negative effects on juvenile salmon. More interesting however were the results of direct river releases downstream. In two of 3 years, more downstream direct releases were detected (more successful) than pond migrants, and in year three there was no significant difference between AP migrants and fish released directly

The use of PIT tag technology allowed WDFW to more fully understand what constituted a successful smolt. Heightened awareness over ESA listed species, helped to encourage management agencies to act responsibly to recover those populations. Any improvement in the general smolt quality of hatchery fish that results in increased emigration is desirable. An increased out-migration, decreases interaction with wild fish. Results from the study showed that larger, leaner fish which emigrated from the AP were more successful migrants than fish which did not migrate volitionally from the AP.

Early conclusions based on our study results (Viola and Schuck 1995) seemed to support continued use of the AP for steelhead releases, with non migrant fish retained in the pond. Confounding this conclusion, however, were the data for direct releases down-river, which, for the purpose of this study, were remarkably successful. Coupled with the benefits of down river release being outside primary spawning/rearing habitat for spring chinook salmon, and the relative ease of direct releases, it represented an acceptable alternative release strategy in an ESA environment. Regardless of release type, the consistency of data among groups showed that large, lean, smolts were the fish detected as active migrants heading seaward.

Data for SARs for the study period are still incomplete. Preliminary results appear to be following those of the 1991-1993 study (Figure 3) which showed that direct releases of smolts at Marengo and into the Tucannon River at Curl Lake AP, performed consistently better than the acclimated release from Curl Lake AP(Schuck et al. 1997). The data do not support the original management supposition that acclimation of fish prior to release will improve survival and emigration performance. Further, there is no data from either study which suggest that direct releases are straying more than acclimated releases, another presupposed benefit of acclimation.

As a result of the study, Management Biologists made the following decisions/changes in how the program was conducted:

1. Release of steelhead from Curl Lake AP was curtailed. Direct stream releases below chinook rearing areas was begun. This change was supported by the data which indicated that out-migration of direct releases equaled or exceeded AP releases. Further, by moving

steelhead releases downstream, most potential negative interactions between them and juvenile spring chinook salmon were eliminated, a highly desirable end result from the NMFS/ESA perspective.

2. Size at release criteria for LFH steelhead production was modified from 5.0 fpp to 4.0-4.5 fpp, to more closely resemble successful migrants observed in the study. Data collected provided sufficient support for this production change despite concerns expressed by WDFW management and NMFS personnel.

3. M&E follow-up to confirm continued success of hatchery smolts to survive is required.

4. Curl AP was made available for the chinook recovery program under ESA in a critical habitat area.

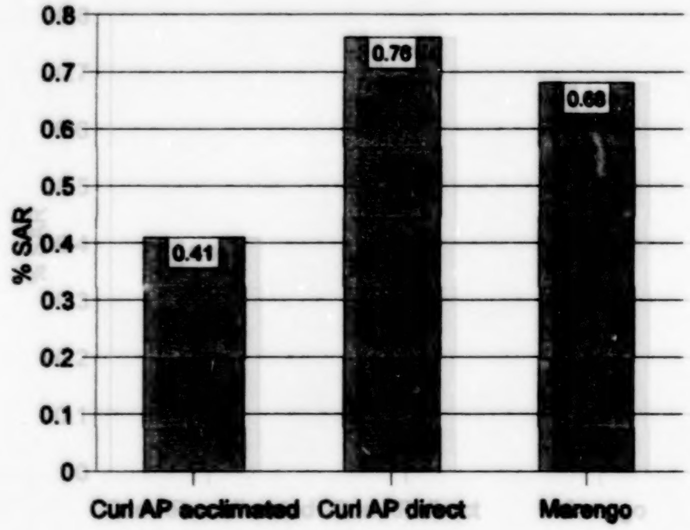

Figure 3. SARs for steelhead releases into the Tucannon River, 1991-93.

Conclusion

The 1994-97 tagging study conducted on Tucannon River steelhead releases provided critical information to management at a critical time. The study was far from classic in its design and completion, and violated some basic tenants of study design that would preclude the acceptance of its results in a peer-reviewed journal. However, the ability of M&E staff to respond quickly to the changing needs of management in an ESA environment, and provide sufficient data upon which reasonable and necessary decisions could be based were invaluable. In the end, wild salmonid populations in the Tucannon River benefitted because of an existing M&E program designed to evaluate a large hatchery program.

Literature Cited

Schuck, Mark L., Arthur E. Viola and Michael G. Keller. 1994. Lyons Ferry Evaluation Study: 1992-93 Annual Report. Washington Department of Wildlife Report # 94-06.

Schuck, Mark L., Arthur E. Viola and Jerry Dedloff. 1997. Lyons Ferry Trout Evaluation Study: 1995-96 Annual Report. Washington Department of Fish and Wildlife Report #H97-08.

U.S. Army Engineer District, Walla Walla, WA. 1975. Special Report: Lower Snake River Fish and Wildlife Compensation Plan. 95 p. plus appendices.

Viola, A. and M. Schuck. 1995. A Method to Reduce the Abundance of Residual Hatchery Steelhead in Rivers. North American Journal of Fisheries Management 15(2) 488-493.

THE KALAMA RIVER WILD BROODSTOCK STEELHEAD PROGRAM: COMPARISONS OF CONTEMPORARY AND TRADITIONAL HATCHERY PRACTICES

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Abstract

WDFW is evaluating the use of wild steelhead as broodstock at the Kalama Hatchery Complex (SW Washington) as part of a multi-year study. Two projects have begun: (1) a winter-run project to compare performance of wild broodstocks in the hatchery to traditional domesticated broodstocks, and (2) a summer-run project to compare the natural reproductive performance of wild broodstock reared in the hatchery to the performance of their wild-reared counterparts. Fecundity of broodstock and survival, growth, and outmigration characteristics of their offspring were compared among 1998 BY winter-run groups. Similar data are being collected from 1999 BY winter- and summer-run fish. Ultimately, smolt to adult return for SR and WR fish and, especially, spawning success of adults from SR smolt plants will be compared to that of wild reared counterparts for three brood years.

Introduction

Studies of steelhead genetics, ecology, and life history have been ongoing in the Kalama River since the mid-1970's. The primary objective of Kalama research to date has been to assess the relative reproductive performance and contribution of hatchery compared to wild steelhead spawning in the wild. For the purposes of this report, wild fish are defined as naturally produced fish, regardless of ancestry, and hatchery fish are those spawned and reared for some portion of their life in the hatchery environment. Earlier Kalama work has shown that highly domesticated steelhead of non-local origin (both summer and winter races) exhibit much lower natural reproductive success than sympatric wild fish (Chilcote et al.1986; Leider et al. 1990; Hulett et al. 1996). This report presents preliminary information on an evaluation of the use of locally derived wild broodstocks (summer- and winter-run) in the Kalama basin.

The use of local wild broodstocks in hatchery programs is receiving considerable attention by WDFW (e.g.,Wild Salmonid Policy [WSP], Steelhead Management Plan, Lower Columbia Steelhead Conservation Initiative) and other agencies responsible for fish management in the Pacific Northwest (NMFS, ODFW, CDFG, IDFG, BCDE). Wild broodstocks are increasingly being used or recommended for use in supplementation applications (intended to increase natural production of depressed stocks) and also in harvest augmentation applications (intended to provide harvest opportunity). Current theory indicates that genetic risks to wild populations might be contained if the degree of genetic similarity between hatchery and wild stocks is high (e.g. Krueger et al. 1981; Allendorf and Ryman 1987; Fleming and Gross 1993). The presumption is that hatchery programs based upon or integrating locally adapted wild fish as broodstock would pose the least risk to wild populations. Alternatively, interbreeding between wild fish and fish domesticated for any number of generations may pose an unacceptable level of risk by causing shifts in genetically based performance traits and affecting survival (Reisenbichler 1996). To date, direct and conclusive empirical evidence in support of either conjecture is lacking. Primary goals of the investigations are to develop wild broodstock steelhead programs, identify risks imposed upon natural production by those programs, and identify strategies to manage those risks.

Methods

Winter-run Project: Three WR hatchery groups were created in 1998: (1) fish from wild Kalama broodstock (KW), (2) fish from the traditional Beaver Creek Hatchery broodstock reared from the fry stage at Kalama facilities (BCK), and (3) Beaver Creek fish reared at the Beaver Creek facility and trucked to an acclimation pond as smolts for final rearing (BCBC). Broodstock for the Beaver Creek groups were adult returns from earlier smolt plants into the Kalama. Race and origin of all spawners was established using run timing, appearance, and presence or absence of fin clips. Juveniles from each group were uniquely marked with blank wire tags, reared, and released from a common rearing pond in the upper Kalama watershed. Similar groups created in 1999 are being reared now.

Sexually mature broodstock were captured as they entered a fishway trap at the Kalama Falls Hatchery (KFH) during the peak run timing of the respective groups and most were immediately live-spawned using the air injection method for females and strip spawning for males. In 1998 the eggs were fertilized following standard hatchery protocols using approximately 5-fish pools for Beaver Creek origin fish and 1:1 spawning for the wild-origin fish. In 1999 all fish were spawned using a partial factorial cross (2 X 2) to increase the effective breeding size of the population (Busack et al. in prep.). Milt was checked for motility before being used to fertilize eggs. Eggs from individual females were incubated separately in shallow troughs or stacks. Fecundity estimates were obtained by counting a weighed subsample of green eggs or by counting eyed eggs and adding back mortalities. After hatch, families were pooled within groups and reared using standard practices for BCK and BCBC fish. A more aggressive feeding regimen including frequent hand feeding and the use of belt and demand feeders was necessary for KW fish. All three groups were wire tagged before transfer in February 1999 to Gobar Pond, an acclimation site in the upper watershed, for final rearing. Wire tags were inserted in different positions so juveniles could be assigned to their groups after pooling. The smolt release was accomplished using a volitional strategy. Rearing fish were sampled monthly to obtain estimates of length, weight, fin condition, and an index of smolt appearance (silver coloration, lack of parr marks, black band on caudal fin). Similar data were obtained on a weekly basis from fish exiting Gobar Pond after active migration began on 5/4/99. Exiting smolts were tagged with photonic tags to allow determination of exit time of migrants captured either in a downstream smolt trap or during sampling for residuals (fish that did not emigrate) in the acclimation pond and in Gobar Creek. The screw-type smolt trap was located at KFH approximately 12 miles downstream from Gobar Pond. Residual fish were enumerated by snorkel survey and sampled by electroshocking and angling.

Summer-run Project: Wild Kalama summer-run steelhead were collected systematically from throughout the run in 1998 and held until spawning in covered ponds at KFH and at the Skamania Hatchery. The broodstock were held at two different facilities to minimize the risk of losing all the fish in any one catastrophic event. Pond covers were constructed of floating PVC frames covered with opaque plastic or netting. The covers precluded jumping and provided hiding cover but still allowed sufficient natural light into the ponds for photoperiod mediated final maturation of the fish. Adults held at both facilities received prophylactic formalin treatments to control disease and were disturbed as little as possible to avoid stress. Broodstock were sorted by sex in December with males sequestered downstream from the females. Females were periodically checked for ripeness beginning in late December, 1998. Spawning was carried out as described above for the 1999 winter-run. The first brood is rearing now and preliminary sampling for growth characteristics follows the methods described above for winter-run.

Results and Discussion

Winter-run Pilot Project: In 1998 a total of 84 Beaver Creek origin fish and 24 wild Kalama broodstock were spawned. Fecundity averaged 4500 and 3200 eggs/female for wild and hatchery WR broodstock, respectively. Fertilization rates (green to eyed eggs) were high (mean 84%) but variable among individual spawners (range 54 to 97%). Green egg to smolt survival was between 60 and 70% among the three groups. Growth trajectories (Fork Length and Weight; Figure 1) were parallel for all three groups but hatchery origin fish were larger throughout juvenile development than the later-spawning (by approximately 3 months) wild broodstock fish. Fish from all three groups exhibited identical changes over time in smolt index (Figure 2). The majority (approximately 80%) of fish from the three WR groups combined smolted and migrated past a smolt trap in the lower basin but apparent residualism of wild origin fish was higher than that of either hatchery origin group (Figure 3). Comparable data are being collected from the 1999 WR brood being reared now.

Summer-run Project: A total of 54 summer-run adults were collected between 5/26/98 and 10/16/98 (Figure 4). For BY 1999 SR, adult survival was greater than 90% over a period that spanned up to 9.5 months (average 7 months). Spawning commenced on 2/3/99 and ended on 4/26/99 with peak spawning in March. Fecundity of the SR adults was 4200 eggs/female, considerably higher than the original estimate of 2600 eggs/female based on earlier work with wild Kalama summer-run. Five adults were released before spawning because the higher fecundity meant adequate numbers of eggs could be obtained with fewer females. Fertilization rates and hatching rates were high overall (88% green to eyed egg survival) but variable among individuals (range 53 to 99%). Green egg to fingerling survival is approximately 84% to date and growth rates are greater than for the comparable WR fish the previous year. Collection of SR broodstock for spawning in 2000 is ongoing with a survival rate at 97% to date.

Acknowledgments

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Literature Cited

Allendorf, F.W. and N. Ryman. 1987. Genetic management of hatchery stocks. P. 141-160. In: Population Genetics and Fishery Management. Utter and Ryman, eds. Univ. Wash. Press. Seattle.

Busack, C.A. The effective size advantage of factorial mating in fish hatcheries. In prep.

Chilcote, M.W., S.L. Leider, and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Trans. Amer. Fish. Soc. 115:726-735.

Fleming, I. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Onchorynchus kisutch*) in competition. Eco. Appl. 3:230-245.

Hulett, P.L., C.W. Wagemann, S.A. Leider. 1996. Studies of hatchery and wild steelhead in the lower Columbia region. WDFW Annual Report No. 96-01. 22 pp.

Krueger, C.C., A.J. Gharrett, T.R. Dehring, and F.W. Allendorf. 1981. Genetic aspects of fisheries rehabilitation programs. Can. J. Fish. Aquat. Sci. 38:1877-1881.

Leider, S.A., P.L. Hulett, J.J. Loch, and M.W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88:239-252.

Reisenbichler, R. 1996. Effects of supplementation with hatchery fish on carrying capacity and productivity of naturally spawning steelhead populations. p. 81-91 In: Proceedings from a workshop on ecological carrying capacity of salmonids in the Columbia Basin. G. Johnson, D. Neitzel, W. Mavros, N.Peacock, eds. BPA Final Report. Project No. 93-012.

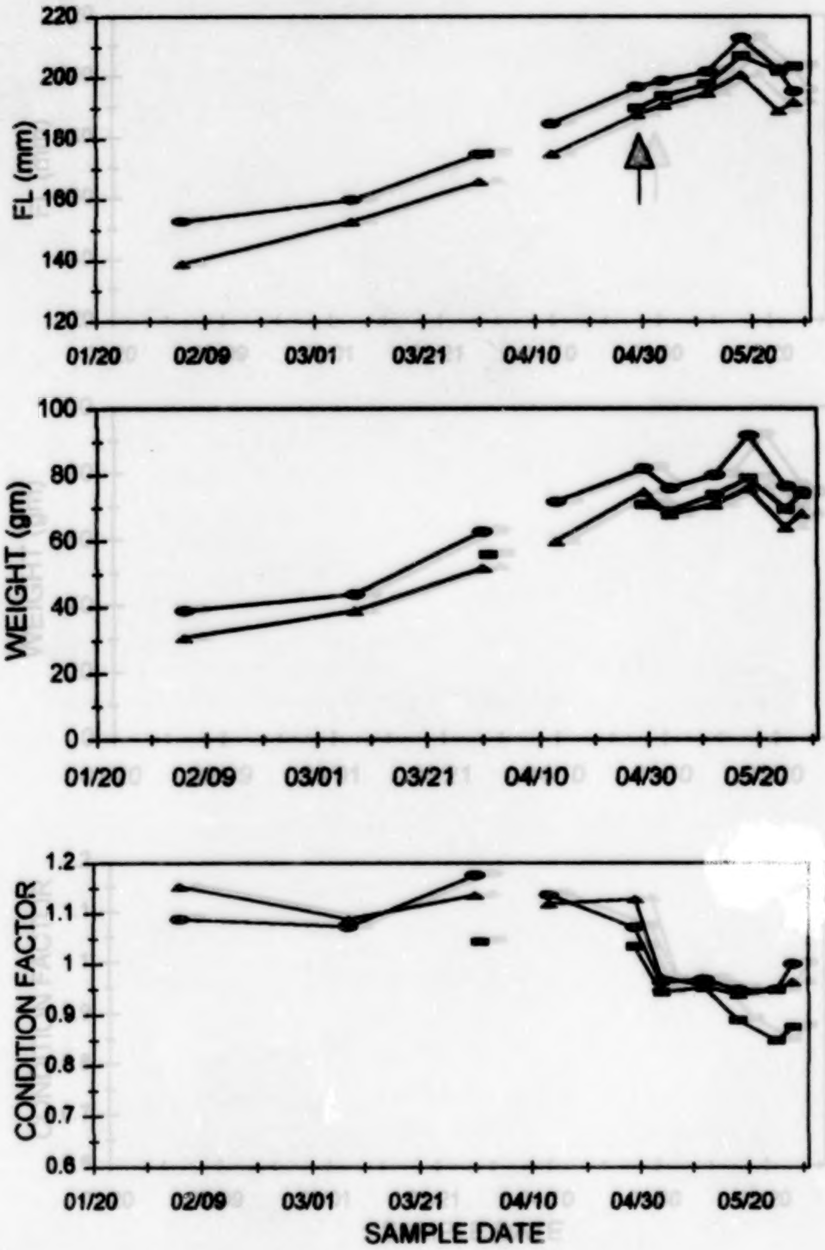

Figure 1. Fork length, weight, and condition factor of BY98 WR steelhead during final rearing and after initiation of volitional release (arrow; top panel). Circles and squares are Beaver Creek origin samples reared at the Kalama and Beaver Creek Complexes, respectively. Triangles are samples from wild broodstock fish.

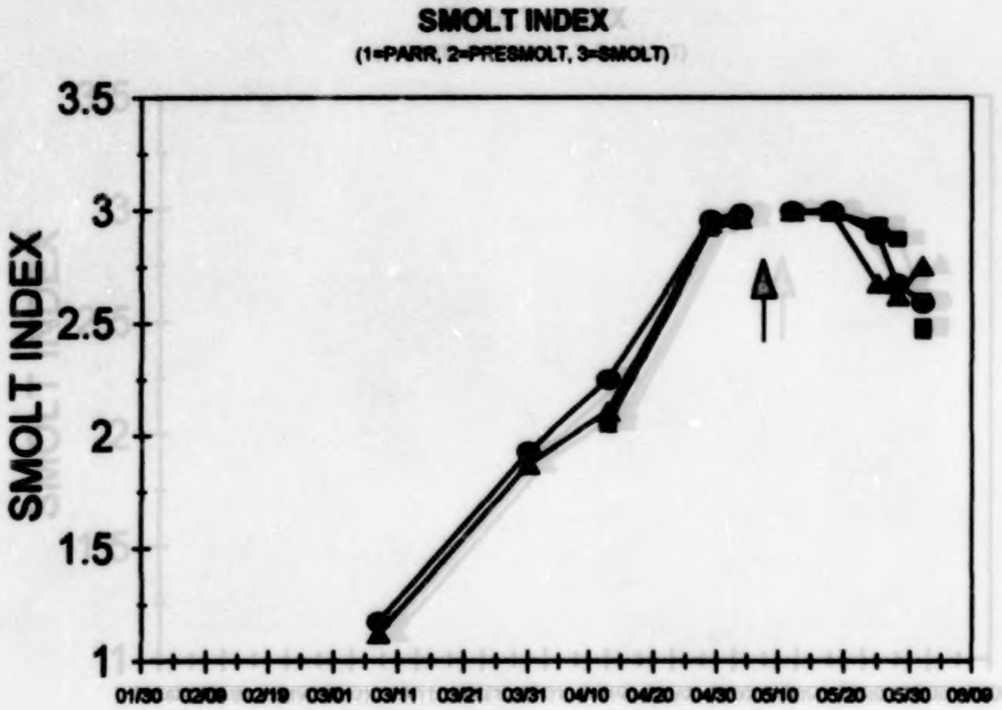

Figure 2. Smolt index during final rearing and release of BY 98 WR steelhead. Circles and squares are Beaver Creek origin samples reared at the Kalama and Beaver Creek Complexes, respectively. Triangles are samples from wild broodstock fish.

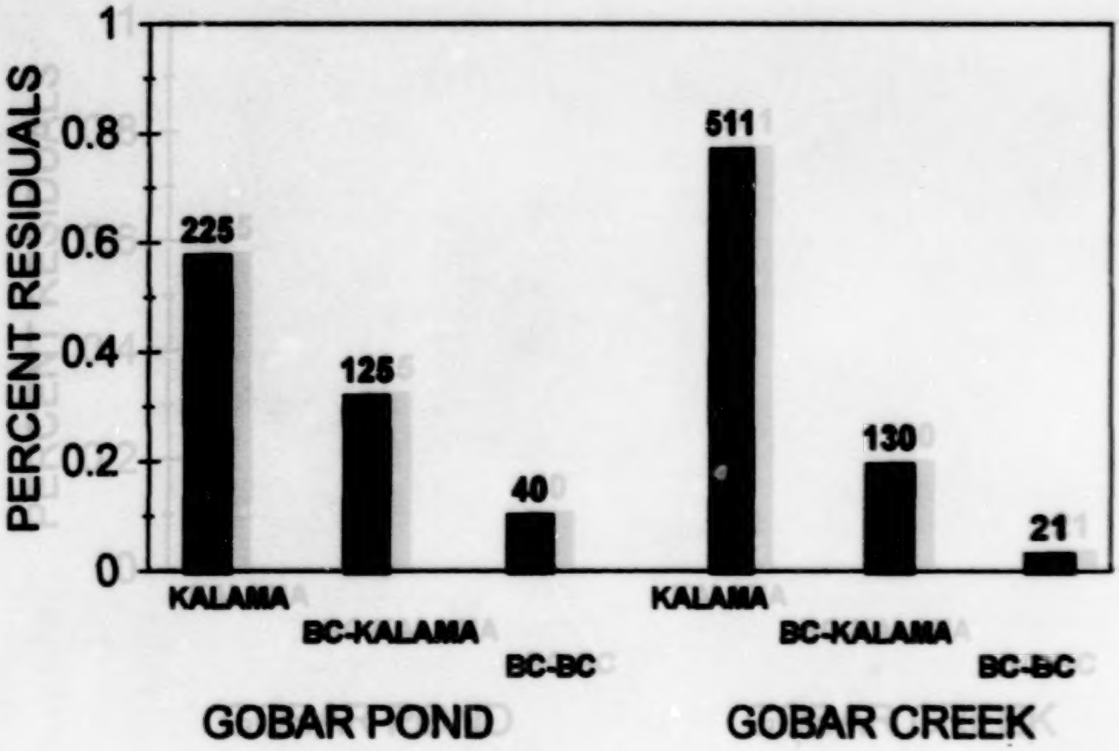

Figure 3. Proportion of fish from three release groups in Gobar Pond at end of volitional release (on 6/1/99; black bars) and in Gobar Creek after 6/15/99 (cross-hatched bars). Kalama, BC-Kalama, and BC-BC refer to wild broodstock, Beaver Creak reared at Kalama, and Beaver Creek reared at Beaver Creek, respectively. Numbers above bars are sample sizes.

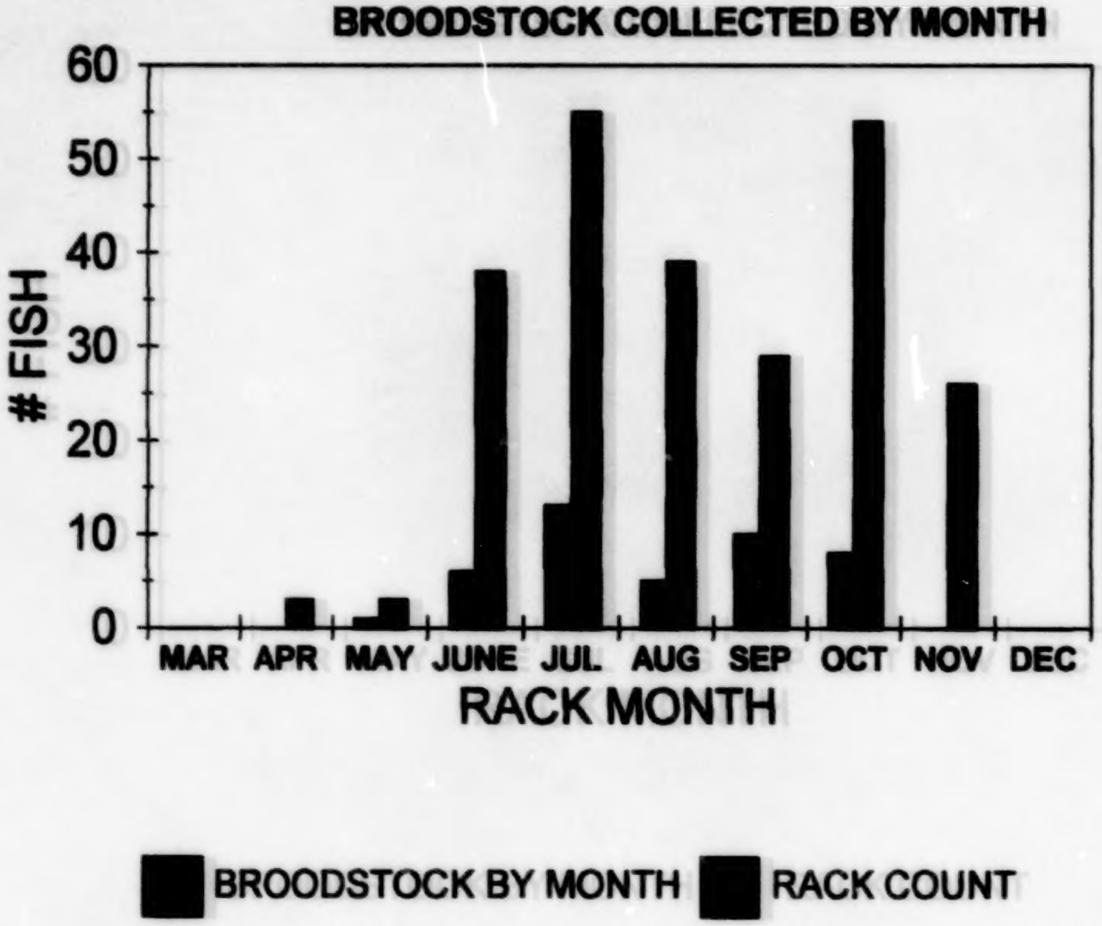

Figure 4. Collection of summer-run broodstock in 1998 (for spawning in 1999) and rack count over the same time period.

Session III:

Fish Health

Session Chair:

Ray Brunson
USFWS
Olympia Fish Health Center

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- FLAVOR-TABS -
ARE FISH THAT PICKY ABOUT HOW THEY ARE GIVEN THEIR MEDICINE?

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Abstract

Over the past three years, some of the requirements necessary to adequately deliver therapeutic levels of antibiotics to production levels of fish without adding the antibiotic to the feed have been examined. These evaluations utilized bulk products approved for use in the poultry and swine industries. Such products can be utilized in aquaculture under extra-label use by veterinarian prescription. Some of the variables that have been identified for effective therapeutic delivery are pellet antibiotic concentration, the # of pellets available per fish (pellet size / weight), the water temperature, pellet palatability and most recently, there appears to be an increasing demand to insure that the pellets are "non-nutritive". This paper specifically addresses palatability and compares pellets with different flavorings. The results from evaluations conducted at the Entiat and Winthrop NFH's on spring chinook salmon, with "Ery-mycin" (a poultry erythromycin product) will be presented. Palatability was evaluated by measuring tissue levels of erythromycin in the fish after being fed different flavored pellets. A flavor was considered "highly palatable" if tissue residue levels of erythromycin were high and "non-palatable" or of "low palatability" if tissue levels were low. Pellet flavorings included: fish, krill, anise, chocolate, vanilla, garlic, berry, orange, molasses and some combinations of flavors. While tissue residue levels of erythromycin did vary, dependent upon pellet flavor, most of the flavors tested yielded erythromycin tissue residue levels that were considered therapeutically acceptable.

EFFECT OF ERYTHROMYCIN FEED TREATMENTS ON BKD AND SURVIVAL OF SPRING CHINOOK SALMON AT WARM SPRINGS NATIONAL FISH HATCHERY

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Abstract

The effects of erythromycin-medicated feed on bacterial kidney disease (BKD) and survival of spring chinook salmon (Oncorhynchus tshawytscha) has been investigated at Warm Springs National Fish Hatchery since brood year 1993. Control and treatment groups were reared in separate ponds and uniquely coded-wire tagged. Medicated treatments consisted of Aquamycin in BioOregon Biodiet feed. Juvenile fish received the medicated treatment during two 21-day feed trials, one during their first spring (May/June) and the next approximately 90 days later (August/September). The objectives of the study at Warm Springs National Fish Hatchery were to determine the effect of feeding erythromycin on: 1) survival (mortality) rates of juveniles during hatchery rearing, 2) levels of soluble antigen produced by Renibacterium salmoninarum in juveniles, 3) levels of soluble antigen produced by R. salmoninarum in adults at spawning, and 4) survival to adult. Juvenile fish were examined for signs of toxicity and ELISA techniques were used to index detection of BKD. Overall health, survival and growth was also monitored. Coded-wire tags were used to compare release to adult recovery survival of each treatment group. Preliminary results have not shown a consistent difference in occurrence of BKD in control and treatment groups in juvenile fish. However, there was a consistent adult survival advantage for the medicated treatment groups. The smolt- to- adult survival rate and adult yield from using medicated feed at the hatchery was the difference between having and not having a sustainable production program for broodyears 1993 through 1995. This study is on-going and is planned to continue at least through the 1998 brood. Adult recoveries will be assessed through return year 2003.

ERYTHROMYCIN FEED TREATMENT CAN REDUCE THE OSMOREGULATORY ABILITY OF JUVENILE CHINOOK SALMON IN SALTWATER

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Abstract

Erythromycin treatment is a frequently prescribed therapy for Bacterial Kidney Disease (BKD), a common obstacle to the artificial propagation of chinook salmon (Oncorhynchus tshawytscha). Typically these propagation programs release smolts with the expectation that they will migrate quickly to the ocean. However, the effect erythromycin may have on the ability of smolts to osmoregulate once they reach seawater has not been fully explored. We examined erythromycin's effect on the osmoregulatory ability of juvenile chinook salmon in saltwater. During August and September 1997, post-smolts were fed erythromycin treated feed at a target dose of 100 mg / kg body weight^{-1} / day^{-1} for 28 days. From March through June 1998, smolts were fed erythromycin treated feed at a target dose of 100 mg / kg body weight^{-1} / day^{-1} either every day for 28 days or every other day for 84 days. Control groups for both years were fed non-medicated feed. After a 9-11 day detoxification period, osmoregulatory ability was evaluated using a saltwater challenge (SWC) in 1997 and 1998. In 1998 a salinity tolerance test (STT) was done, gill Na^+/K^+ ATPase activity was measured, and tissue samples were analyzed to determine the erythromycin concentration in the posterior kidney, anterior kidney, brain, and liver. In 1997 the post-smolts in the 28 day treatment group had a reduced ability to regulate Na^+ ions in saltwater. In 1998 smolts fed erythromycin every other day for 84 days had significantly higher mortality in a STT than the control group. However, in 1998, treatment with erythromycin did not affect the ability of smolts to regulate Na^+ ions in saltwater or influence the Na^+/K^+ ATPase activity in their gill tissue. In 1998 both treatment groups had higher levels of erythromycin in the liver, posterior kidney, and anterior kidney than the controls. Overall, these data suggest that feed treatment with erythromycin results in the accumulation of the antibiotic in certain tissues and can reduce the ability of hatchery smolts to osmoregulate and survive in seawater. Thus, fish culturists who use erythromycin as a therapy for BKD should consider the timing of treatment with respect to smolt outmigration.

MANAGING *MYXOBOLUS CEREBRALIS* INFECTIONS AT TWO IDFW-OPERATED CHINOOK HATCHERIES IN THE UPPER SALMON RIVER

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Abstract

Myxobolus cerebralis, the parasite that can cause whirling disease, was first detected in 1987 in juvenile chinook salmon at two upper Salmon River hatcheries operated by Idaho Department of Fish and Game (IDFG). These mitigation facilities, Sawtooth Fish Hatchery (LSRCP) and Pahsimeroi Hatchery (Idaho Power) have limited ground water available and have to rely on river water for smolt production. As expected, the open river water supplies of both facilities were demonstrated to contain the infectious stage of the parasite while the well water supplies did not. IDFG applied methods used successfully in European trout culture to minimize the prevalence and intensity of M. cerebralis infection. Specifically, chinook were reared on well water to a minimum length of 75 mm and weight of 3.5 g (3", 130 fpp) before juveniles were exposed to river water. The two facilities differ on the type of final rearing containers used: Sawtooth has cement raceways for rearing to the smolt stage while Pahsimeroi has earthen and gravel bottomed ponds.

At Sawtooth,, prior to adopting the delayed exposure strategy, chinook juveniles of BY 85 - 93 were reared on well water until May before ponding onto river water at a size of about 45 mm. Sawtooth chinook of BY 94 to the present have been reared on well water into August before being exposed to river water. At Pahsimeroi, ponding of BY 85 – 93 was carried outdirectly on river water at swim-up in December through February. Delayed exposure was accomplished by rearing BY 95 – 97 Pahsimeroi chinook on well water at Sawtooth until July. Chinook at each facility have been routinely examined by the pepsin/tryspin digest method prior to release as part of our fish health monitoring program. These data were used to evaluate the effectiveness of this delayed exposure rearing strategy and to compare culture in cement raceways with earthen pond culture.

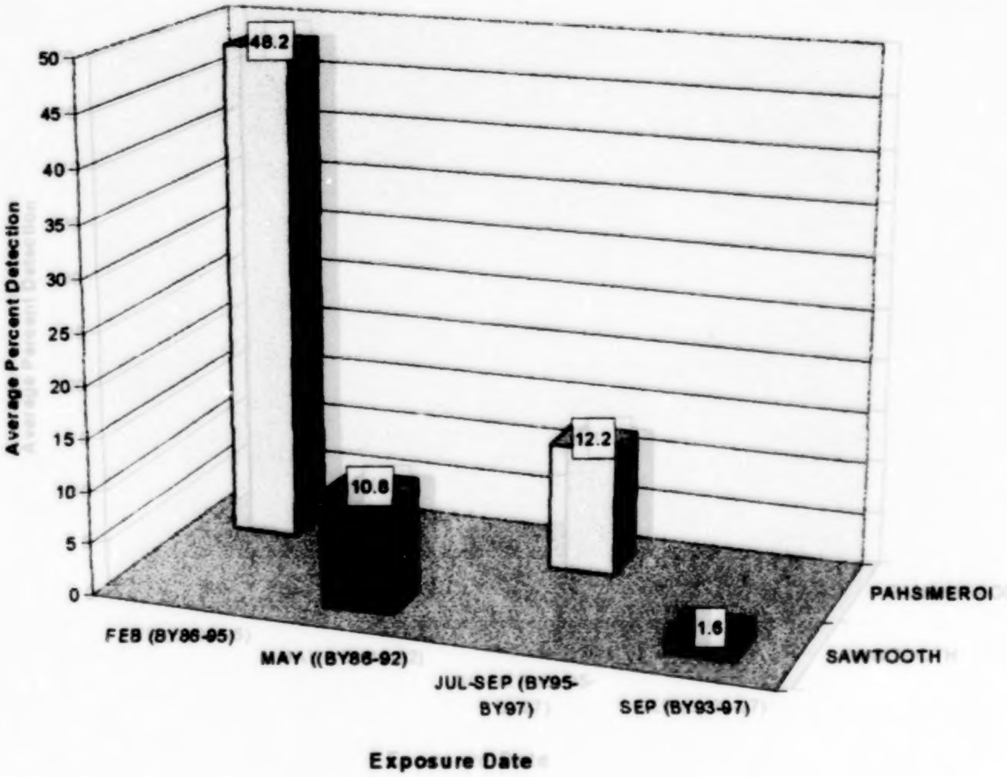
Results of IDFG's annual monitoring of pre-release smolts demonstrated a reduction in the detection of M. cerebralis at both facilities as the result of this delayed exposure to river water. Detections at Sawtooth and Pahsimeroi hatcheries were reduced from 11% to 1.6% and from 48 % to 12% respectively.

It is interesting to note that the infection level at Sawtooth prior to adopting the delayed exposure is the same as that found with naturally produced chinook juveniles from the

upper Salmon River. It appears that the level of challenge was greater at Pahsimeroi than Sawtooth which may be the result of rearing in earthen ponds compared to cement raceways. Pahsimeroi chinook which were raised in river water from swim-up developed whirling disease signs by the end of the first summer whereas chinook at Sawtooth never showed disease signs. There has not been sufficient time for the results of this culture practice to appear as a change in detection of the parasite in adult returns. However, detections of M. cerebralis in adult chinook and steelhead returning to both facilities during the last twelve years have been decreasing. In addition, there has been no correlation of M. cerebralis detection rate as smolts with smolt-to-adult survival for chinook for return years 1988 to 1999, which indicates that factors other than infection rate of the parasite have a greater influence on survival.

Our recommendation for these two related programs is to expand the well water supply at Pahsimeroi Hatchery to allow incubation and early rearing through July on water free of the infectious stage of M. cerebralis and to replace the earthen ponds with raceways. This would eliminate the need to raise Pahsimeroi chinook at Sawtooth and would allow Sawtooth chinook to be consistently reared on well water through the summer.

Effect of Delaying Exposure of Chinook Juveniles to River Water at Sawtooth and Pahsimeroi Hatcheries on Detection of M. cerebralis at Pre-Release Sampling (the Following Spring).



Session IV:

Innovations, Engineering and New Technology

Session Chair:

Bryan Kenworthy
USFWS
Hagerman National Fish Hatchery

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SOCIAL BEHAVIOR AND COMPETITIVE ABILITY OF JUVENILE STEELHEAD (*ONCORHYNCHUS MYKISS*) CULTURED IN ENRICHED AND 'CONVENTIONAL' HATCHERY VESSELS

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Abstract

Steelhead (Oncorhynchus mykiss) along the west coast of North America reside in streams for 1 to 4 (typically 2 or 3) years before migrating to sea. Most hatchery programs designed to augment harvest rear steelhead to the smolt stage in 1 year, and release them. However, recent listings of some steelhead populations under the US Endangered Species Act presents the likelihood that various release strategies, including release as age-0 'fry', will be implemented for steelhead produced from conservation hatcheries. Recent studies conducted at the NMFS Manchester Marine Laboratory involved culturing steelhead from emergence to 50-80 days post-emergence in habitat-enriched rearing tanks (containing a combination of in-water structure, underwater feeders, and overhead cover) and in more 'conventional' tanks.

In laboratory experiments, steelhead fry grown in the enriched tanks socially dominated size-matched competitors grown in conventional tanks. When both groups were introduced into a quasi-natural stream, fish reared in the enriched tanks grew at a higher rate than conventionally reared fish under conditions of mutual competition. However, no differences in growth were found in the absence of competition. A combination of visual isolation and defensible food resources in the enriched tanks were considered as the primary factors causing the observed competitive asymmetries. Steelhead fry from the two rearing environments did not exhibit differences in their use of woody structure in the quasi-natural stream. Rearing steelhead in more naturalistic environments could result in hatchery fish that behave in a manner more similar to wild fish, and therefore, assimilate more naturally into their post-release environment. Current studies are underway to determine whether rearing fish in enriched tanks induces behavioral development that is more similar to that of wild fish.

ENHANCED DIFFUSION OF CALCEIN INTO RAINBOW TROUT FRY USING CAVITATION LEVEL ULTRASOUND

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Abstract

Enhanced diffusion of calcein into rainbow trout, Oncorhynchus mykiss, fry was achieved using cavitation level ultrasound for the purpose of mass marking. Three variables, consisting of two voltage amplitudes (90mV and 120 mV), two calcein concentrations (600 and 900 mg/l) and two treatment durations (5 and 15 min) were examined. Overall mean diffusion of calcein ranged from 0.4 to 36.6 ng/fish. Highest absorption level (36.6 ng/fish) was achieved when highest amplitude, 120 mV was applied for 15 min in 900 mg/l of calcein solution. The least amount of diffusion (0.4 ng/fish) resulted from 90 mV for 5 min in 600 mg/l solution. While 120 mV resulted in 21.9 ng/fish diffusion, 90 mV yielded 11.3 ng/fish and was significantly lower ($P < 0.05$). A calcein concentration of 900 mg/l resulted in a higher ($P < 0.05$) diffusion rate (21.1 ng/fish) than 600 mg/l yielding 11.4 ng/fish. Similarly, the fry treated for 15 min had 23.0 ng/fish of calcein while others treated for 5 min yielded only 9.8 ng/fish. A high level of background autofluorescence (7.4 ng/fish) was measured. Results from these experiments demonstrate that a several fold increase in the rate of diffusion of calcein into fry can be achieved when treated with cavitation level low frequency ultrasound (40 kHz and 90 or 120 mV) and has potential for use in delivery of compounds for marking fish as well as for delivery of therapeutants such as vaccines and antibiotics.

Introduction

Introduction of various compounds into fish has been accomplished through feeding, injection (IM, IP or IV), immersion or power spray treatments. Directly injecting the compound of interest into fish has been the most effective means of delivery (Palm 1994; Johnson and Amend 1983; Ellis 1988). However, disadvantages of this method include 1) individual handling of fish, thus labor intensive and difficult to treat a mass population, 2) stressful to the fish, and 3) difficult to treat during the early developmental stages when mortality associated with diseases etc. is high. A non-lethal, non-stressful means of effectively delivering a controlled dose of compound to a large number of fish is needed to treat for diseases as well as mark (tag) fish for stock management purposes. Preliminary studies indicated that the use of ultrasound facilitates diffusion of compounds such as GnRH or gentamycin across fish skin and gills without causing irreversible damage to its health and well-being (Zohar et al. 1990; Zohar et al. 1994).

Cavitation level, low frequency ultrasound has been used to help shatter kidney stones, produce sonoluminescence and accelerate chemical reactions (Machanshetty et al. 1995; Prosperetti 1986; Apfel 1981). Cavitation occurs in a fluid medium and is induced by low frequency ultrasound. It involves a sequence of events including nucleation, bubble formation, oscillation and implosive collapse of air bubbles. It results from an ultrasound wave which produces alternating areas of compression and rarefaction, and consequently, pressure changes in the fluid (Williams, 1983). Cavitation effects are observed with the onset of ultrasound at 20 kHz, and ceases at frequencies greater than 2.5 MHz (Gaertner 1994). Recent studies in human skin demonstrated that these oscillations and the collapse of bubbles effectively disorganize the lipid bilayer allowing larger protein molecules to diffuse through the skin (Mitragotri, 1995a,b). Since skin and gills are well adapted to exchanging molecules with the external environment, cavitation-enhanced diffusion is thought to be more effective with fish.

Calcein (2,4-bis-[N,N'-di(carbomethyl)-amino-methy]fluorescein) (MW 622) is known to chemically bind with calcium resulting in a marked increase in its fluorescence when complexed with alkaline earth metals (Wallach et al. 1959). This compound has been used to mark a number of fish species in immersion treatments with various concentrations (Mohler 1997; Monaghan 1993; Brooks 1994). Immersion treatments of 2-28 hours were required to diffuse enough calcein with mortality exceeding 41% in some cases. Mohler et al. (1997) conducted only subjective assessment of markings (i.e., visual assessment of the presence or absence of markings). In the present study, a short duration and high concentration immersion treatment, combined with facilitated diffusion using ultrasound, was expected to result in an accelerated rate of diffusion.

The objective of this study was to use the calcein delivery into trout fry as a model system for testing the concept of ultrasound-mediated delivery of compounds into fish. More specifically, we attempted to quantitatively evaluate the level of calcein permeation and retention for 30 days post treatment using cavitation level ultrasound treated for 5 or 15 minutes. This study differs from other previous studies in that we facilitated the diffusion of calcein using ultrasound and measured the level of calcein in the entire fish using quantitative means.

Material and Methods

Rainbow trout fry (Erwin strain), 30 day post-hatch (n=80) were randomly selected for each treatment. Four repeats of 20 fish each were placed inside of a plastic test tube (2.5-cm diameter and 3.0 cm deep) containing calcein (Sigma, St. Louis, MO) concentrations of 600 or 900 mg/l. The test tube was then placed inside of a cylindrical piezoelectric crystal ceramic transducer type Vernitron H-1 (NRL, Orlando, FL) of 2.8 cm inside diameter. Constant frequency at 40 kHz and amplitude of 90 or 120 was applied for 5 or 15 min duration. Control fish either received no ultrasound treatment or received an ultrasound treatment without calcein. Fish were immediately removed post-treatment, rinsed and placed in a 74 L rectangular aluminum rearing tank (35.6 cm x 101.6 cm x 20.3 cm).

The transducer at this power intensity tended to heat and increase temperature of the solution as much as 10° C. Constant flow of chilled water (7° C) outside of the test tube maintained constant temperature of the calcein solution (10-12° C). A thin plastic straw attached to the air line was inserted along the test tube wall to provide continuous aeration during the treatment. A digital thermometer with a flexible type T thermocouple (HH-25TC, New York, NY) was also inserted into the test tube to monitor the temperature flux (Diagram 1). All ultrasound treatments were completed within 3 days.

Ultrasound Instrumentation

A cylindrical piezoelectric crystal transducer (PZT) with 2.8 cm inside diameter and 2.5 cm deep was driven by 2100RF-power amplifier (EIN, Rochester, NY). This PZT contains lithium sulfate crystal that is vary stable under varying temperatures and hydroacoustic pressures. The amplifier that drives the PZT was connected to the LeCroy 9100 arbitrary function generator (LeCroy, Burlingame, CA). This function generator was then attached to a hand held keypad that facilitated in selecting frequency levels, voltage amplitude and duration of signal (Diagram 1). Wave form output was monitored and read by the Tektronix 2236 oscilloscope (Tektronix, Beaverton, Oregon).

Calcein Detection

Juvenile fish (n=5) from each treatment were randomly selected and frozen 21 days after treatment for analysis. Each frozen fry was homogenized with 250 µl of Tris-buffered saline (TBS) (0.02 M Tris/0.13 M NaCl, pH 7.8) containing 0.01M EDTA and 1% Triton X-100 (Sigma, St Louis, MO, USA) in a 1.5 ml microfuge tube using Cframo RZR-1 homogenizer (Cframo, Ontario, Canada) with a fitted pestle tip (Kontes, CA, USA). The homogenate was centrifuged at 14,000 rpm on a Eppendorf microcentrifuge for 30 min and the clear supernatant was collected. The residue was re-extracted with another 250 µl of the previous buffer (TBS/EDTA/Triton X-100) and the pooled supernatant from two extracts was tested for calcein content on a multi-plate reader Cytofluor 4000 (PerSeptive Biosystems, Framingham, MA, USA) at emission 530 nm (excitation at 485 nm). The concentration of calcein in the supernatant was obtained from a standard curve prepared from a two-fold serial dilution of calcein (1 µg/ml to 1 ng/ml) (Figure 1).

Statistical Analysis

This was a completely randomized 2 x 2 x 2 factorial design with ultrasound (90mV and 120mV), calcein concentration (600 and 900 mg/l) and duration of treatment (5 and 15 min) as variables. The treatment effects were determined with Analysis of Variance (ANOVA) by using SAS General Linear Model Procedures (SAS Institute, 1982). Individual fish were considered a replicate of a treatment in this experiment. Type III sums of squares were used to determine significant difference between variables. Mean differences between treatments were also compared with Tukey's (HSD) test. All comparisons are presented at significance level $P<0.05$.

Results

Overall mean absorption of calcein into the post-hatch fry ranged from 0.4 ng to 36.6 ng with an average of 24.2 ng/fish. Highest absorption level was obtained when highest voltage, 120 mV was used for 15 min in 900 mg/l of calcein. Only a small quantity (4.2 ng) permeated the fish that was treated with 90 mV for 5 min in 600 mg/l of calcein. Mortality of less than 1% was comparable to that of the control.

Overall quantity of calcein extracted form fry treated with 120mV was higher (21.9 ± 2.89) than those treated with 90 mV (11.7 ± 2.07) ($P>0.05$). Control fish that were immersed in calcein solution for the same duration without ultrasound treatment had significantly lower levels (0.8 ± 0.74 ng) of permeation ($P<0.05$) (Figures 2 and 3).

Higher calcein concentration (900 mg/l) resulted in higher diffusion rate (22.1 ± 3.31 ng) than lower concentration (600 mg/l) with 11.4 ± 1.76 ng/fish ($P<0.05$) (Figures 2 and 3). A significant amount of overall background autofluorescence (7.4 ng/fish) was detected in control fish that did not receive calcein treatment. Thus, this value, 7.4 ng/fish, was subtracted from results of all treatments reported. Larval fish treated for 15 min had a higher amount of calcein (10.5 ± 2.01 ng/fish) than those treated for only 5 min (4.84 ± 1.18 ng/fish) ($P<0.05$). All controls (i.e., bath immersion in 600 or 900 mg/L calcein without ultrasound; 90 or 120 mV ultrasound treatment in baths without calcein; 5 or 15 min bath immersions without ultrasound or calcein) had similar levels of autofluorescence (6.6-8.8 ng/fish) and were not significantly different from one another ($P>0.05$).

A difference was found between all variables and no two-way interactions between duration of treatment, amplitude or concentration were observed. However, three-way interaction of these three variables was found to be significantly different ($P<0.05$).

Discussion

This is the first quantitative study to report enhanced permeation of a compound into fish using cavitation level ultrasound. Fish skin and gill tissues are involved in actively exchanging chemicals from the external environment (Gorman 1982; Laurent and Dunel 1978). However, the rate at which this exchange takes place is determined by numerous variables including chemical size, structure, composition, concentration, water temperature, etc. Cavitation apparently can overcome some of these barriers and allow a higher rate of diffusion across the skin and gills.

The composition of extraction buffer (TBS/EDTA/Triton X-100) was found optimal for the extraction of most of the adsorbed calcein. To optimize the concentration of EDTA and Triton X-100 in the extraction buffer, spike tests with known amounts of calcein in frozen fry were performed. After two extractions of the calcein from spiked frozen fry with 0.01 M EDTA and Triton X-100 in TBS (pH 7.8), almost 100% of the calcein was recovered.

Because of its relatively small size (622 MW), calcein will diffuse into fish by simple immersion (Mohler 1997). However, immersion duration of 48 h is time consuming and detrimental to fish health with significant mortality (>10%). Results, though useful, were not quantified. In the present study, we were successful in achieving an enhanced diffusion rate as high as 36.6 ng/fish in 15 min. This was achieved by treating fry with ultrasound (120 mV at 40 kHz) in 900 mg/l of calcein.

Duration of treatment significantly affected the rate of diffusion. However, long term treatment with cavitation (15 min) created anoxic conditions resulting in a lowered level of oxygen in the calcein solution and presumably also lowered cavitation effect due to the lower amount of dissolved gases present. A similar condition was observed by Mitrogotri et al. (1995a). Continuous aeration of the solution prevented this problem from occurring. Aeration of the solution created a foamy condition, due to the presence of Triton X 100, making it difficult to observe fish behavior. This problem was overcome by reducing the air pressure and exchanging solution after each treatment.

Significant variation in the diffusion rates between individual fish was observed. This variation in the amount of calcein diffusion between individual fry may have been due to fish size variation. Since, these were 30-day old fry, there was a noticeable size variation. Smaller quantities adsorbed by smaller fish combined with a greater portion of the bound calcein lost during the extraction from larger size fish may have contributed to this variability. Significant autofluroscence was detected as indicated in the results. A similar problem with background fluorescence was also reported by Koenings et al. (1986) and Mohler (1997). There was some (1-2-ng/fish) loss of calcein during the extraction and transfer.

The highest calcein concentration treatment yielded higher total recovered calcein. This is consistent with the Beckman et al. (1990) report that the highest calcein bath concentration yielded the brightest calcein mark in the otolith of spotted seatrout, *Cynoscipion nebulosus*.

The results of the preliminary marking study conducted at the Center of Marine Biotechnology in Baltimore, MD, differed significantly from the experimental results obtained at the Bozeman Fish Technology Center in Bozeman, MT. Acoustical parameters used in Baltimore were 300 and 600 mV at 40 kHz. This resulted in a significantly higher rate of diffusion (over 100 ng/fish in many cases) when compared with that of the control. However, similar acoustical parameters resulted in 100% mortality in Bozeman. A new lethal dose had to be assessed for this prior to the initiation of the treatments. Elevation differential from sea level in Baltimore, MD to over 4,800 feet above sea level in Bozeman, MT is thought to have caused the difference in these results. In other words, even a higher rate of diffusion, than the currently reported, may be possible at a lower elevation or under controlled pressure conditions.

The need for new approaches of compound delivery into fish is generally recognized within the industry and academic communities These results magnify the potential of this novel technology for ultrasound-enhanced delivery of beneficial compounds into eggs, fry, juveniles, etc., not only as a cost effective approach, but also as the most practical means for rapid and efficient uptake of therapeutants and markers.

Acknowledgments

We thank Ennis National Fish Hatchery for supplying rainbow trout fish eggs and the staff members of the Center of Marine Biotechnology and Bozeman Fish Technology Center for their technical assistance with this study. We also thank the U.S. Geological Survey, Technology Enterprise Office for funding this research and the U.S. Fish and Wildlife Service, Washington Office for administrative support.

References

Apfel, R.E. 1981. Acoustic cavitation. In Methods of experimental physics. Academic Press, New York.

Beckman, D.W., C.A. Wilson, F. Lorica, and J.M. Dean. 1990. Variability in incorporation of calcein as a flurosescent marker in fish otoliths. pp. 547 In N.C. Parker ed. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, MD.

Brooks, R.C., R.C. Heidinger, and K.C. Christopher. 1994. Mass-marking otoliths in larval juvenile walleyes by immersion in oxytetracycline, calcein and calcein blue. North American Journal of Fisheries Management 14:143-150.

Ellis, A.E. 1988. Optimization factors for fish vaccination. In "Fish Vaccination" (A.E. Ellis, ed.) pp. 32-46, Academic Press, London.

Gaertner, W. 1954. Ultrasound and its effects. Journal of the Acoustical Society of America 26:977-980.

Gorman, D. B. 1982. Histology of the striped bass. American Fisheries Society Publication. Bethesda, MD 59-61pp.

Johnson, K.A., and D.F. Amend 1983. Comparison of efficacy of several delivery methods using *Yersinia ruckeri* bacteria on rainbow trout, *Salmo gairdneri*, Richardson. Journal of Fish Diseases 6:331-336.

Koenings, J.P., J. Lipton, and P. McRay. 1986. Quantitative determination of oxytetracycline uptake and release by juvenile sockeye salmon. Transactions of the American Fisheries Society 115:621-629.

Laurent, P., and S. Dunel. 1978. Histophysiologie-relations anatomiques des ionocytes (cellules a chlorure) avec le compartment veineux branchial: definition de deux types D'epithelium de la branchie des poissons. Comptesrendus Academic de Sciences Paris, Serie D:1447-1450.

Machanshetty, S.I. 1995. Conceptual model for acoustic microcavitation. Journal of the Acoustical Society of America 98(5):2681-2689.

Mitragotri, S., D. Blankschtein, and R. Langer. 1995a. Ultrasound-mediated transdermal protein delivery. Science 269:850-853.

Mitragotri, S., D. Blankschtein, and R. Langer. 1995b. A mechanistic study of ultrasonically-enhanced transdermal drug delivery. Journal of Pharmaceutical Sciences 84(6):697-706.

Mohler, J.W., 1997. Immersion of larval Atlantic salmon in calcein solutions to induce a non-lethally detectable mark. North American Journal of Fisheries Management 17:751-756.

Monaghan, J.P., 1993. Comparison of calcein and tetracycline as chemical markers in summer flounder. Transactions of the American Fisheries Society 122:298-301.

Palm, R.C., M.L. Landolt, and R.A. Busch. 1994. Specific humoral response of rainbow trout to injection, immersion, and oral immunization against *Vibrio angullarium*. International Symposium on Aquatic Animal Health, Seattle, WA 4-8 September, 1994.

Prosperetti, A. 1986. Physics of acoustic cavitation. Physics of Acoustics XCIII:145-188.

Wallach, D.E.H., D.M. Surgenor, J. Soderberg, and E. Delano. 1959. Preparation and properties of 3,6-dihydroxy-2,4-bis[N-N'-di(carbomethyl)-amino-methyl] fluorescein) utilization of the ultraelectrode termination of calcium. Analytical Chemistry 31:456-460.

Williams, A.R. 1983. Ultrasound: Biological effects and potential hazards. Academic Press, New York.

Zohar, Y., A. D'Emanuele, J. Kost, and R. Langer. 1990. "Ultrasound-mediated administration of compounds into aquatic animals." International Patent No. 07/583,573 (approved).

Zohar, Y., D. Doring, and R. Langer. 1994. Application of controlled-release technology in aquaculture. Proceedings of the International Symposium on Controlled Release of Bioactive Materials 21:110-112.

HATCHERY MANAGEMENT SOFTWARE: A RELATIONAL APPROACH

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Introduction

During the last decade, as salmon runs have declined, the decreasing fisheries opportunities have put a strain on agency funding for enhancement operations. This has forced biologists to search for efficiencies in their enhancement programs. Besides reduced funding, fish culture operations have increased in complexity. Some examples of the new order of hatchery management include: increased genetic and fish health monitoring requirements; INAD, NPDES, and hazardous waste permits; CWT related mass marking, and segregation of stocks for rearing. The result has been increased responsibilities for hatchery staff in operating their facilities to meet these intra-agency and inter-agency requirements. The need for detailed record keeping and reporting has also increased. While many facilities and agencies have developed tools such as spreadsheets and forms to process and report various aspects of fish culture, a software search showed few programs have developed applications that integrate hatchery operations into one relational package.

The Washington State Department of Fish and Wildlife, and the Treaty Tribes of Western Washington, co-managers of the Western Washington fisheries resource, teamed to design and build a relational database that documents the entire operation of their hatcheries. A software design steering committee was selected, and a programmer hired to build the application. The goals of the project include: 1) Design a user friendly program for hatcheries that would enable management of consistent records of each aspect of rearing. 2) Provide reports for use in planning and analysis by the facility. 3) Create exports for the agencies use in interagency reporting.

Application Environment and Structure

Hat-Pro is a database management application that can be used for all types of fish culture. It is designed for use by a PC using 32 bit operating system such as Windows 95/98 or NT. The Hat Pro application is written in the PowerBuilder language, with data stored in Access 97 database format. The database contains 118 related tables. All of the data tables contain a three part hierarchical key: agency/tribe, complex, and facility. This allows hatchery complexes to monitor their individual facilities, and agencies to house the data of all their complexes and facilities. For example, an agency could run a report to inventory quantity, cost, and location, of a particular feed for all of their facilities. Many Windows common tools such as cut and paste, bubble help, windows help, online manual, pull-down windows, and pop-up screens have been incorporated. Some areas of interest are described below.

Environment and Growth

Many environmental parameters that facilities need to monitor are available within the system. These include daily inputs of water and air temperatures, dissolved oxygen, turbidity, ammonia, pH, flow, suspended and settable solids. All of the required data fields are present for storing and reporting NPDES permit data. These can be entered for water sources, ponds and raceways, egg incubation, effluent, or abatement ponds. The user can define multiple water sources. Growth model projections are based on future and current temperatures assigned for each water source. The user can modify the rate of growth with the existing chinook growth model, or create, load, and save their own.

Adult Recovery, Spawning, and Egg Maintenance

Hat-Pro provides hatchery staff complete accounting of all adult recovery, spawning, and egg taking activities. This includes inventory of all adults by species, stock, and run. The number of brood ponds used to segregate spawners is defined by user. Many carcass types are incorporated, including: spawned ok, green, pond mortalities, culled, return to stream, etc. Carcass disposition types can be set and modified by the user such as: surpluses, grade A, or buyer or organization name. A certifiable fish ticket number can be generated for each entry. This provides carcass accountability at the agency level. Entry screens for mark and CWT sampling is included. Many fields are stored in PSC/PSMFC format for reporting by recovery agencies. Egg stages are entered or transferred, as green, eyed, or fry. As with adults, eggs can be transferred on or off station. The user can set current temperature units (CTU) on egg lots. CTU's will accumulate automatically from selected water source daily temperatures. Users can define key CTU based egg stage levels. When eggs approach these levels the application will automatically notify the user. Fecundity, lot #, and location are tracked and stored. Egg picking and mortality are tabulated respectively of stage, lot #, and location.

Pond Management and Forecasting

Feed parameters and price are entered into feed inventory when purchased. As ponds are fed, feed is subtracted from inventories. Cost per fish is accumulated throughout fish life. Mortality by pond and lot # is tabulated until release. Forecasting by pond will generate projected feed amounts, cost, fish growth, and mortality in weekly intervals. Projected density and flow indexes are also calculated for scheduling projected pond splits. Pond splits can be entered as Percentage moved, weight, or actual number of fish moved.

Treatments, Transfers, Releases, and Marking

Treatments can be given as egg locations or ponds, and create records of each chemical or drug usage and diseases treated. In the future, the system will be integrated with an existing fish health database named Aqua Doc. This will combine the hatchery data with pathological treatment and monitoring reports from the fish health labs. Complete fish health data records will exist in the facility database.

All or part of a ponds population can be used when releasing or transferring eggs, fingerlings, or adults. All PSC/PSMFC required fields are present for releases. Pull-down boxes and lookup tables are used for many of these fields. Location name or PSC location codes for example, can be used to select a release site.

When fish are CWT or marked, their status is tracked by location. All mark types and CWT mortality is accrued. If individual fish within a pond are marked or CWT and individual mortality are unknown, a weighted ratio is used based on the entire pond population. As daily pond entries accrue, biomass, density, and flow indexes are recalculated.

Utilities

The program and its associated ODBC drivers are installed on a PC through a Windows setup program. Sites customize their lookup and facility tables with table maintenance screens before entering data. The report's generator contains query criteria selection options for the 36 canned reports. Reports can be viewed, or printed directly to a printer. All reports have been designed with AFS style standards. New reports and queries can be easily written and modified through the Access database program. Exports of predefined format and criteria for use by reporting agencies is also included. These files can be sent via Internet FTP or as email attachments to the agency. Some examples of these are: release, marking, and adult escapement reports. A consolidation utility for merging data is included for exporting and importing data from other similar databases.

ELECTRONIC SAMPLING FOR CODED WIRE TAGS – TO BEEP OR NOT TO BEEP?

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Introduction

The adipose fin clip has historically been reserved to identify salmon carrying a coded-wire tag (CWT). Recent proposals for mass marking hatchery salmon led to a conflict over the use of this fin mark. Despite numerous investigations into alternative marks, the adipose fin clip was determined to be the only suitable visual mark for both purposes. On one hand there was tremendous political pressure to mass mark fish for selective fisheries. On the other hand, all agencies agreed that the integrity of the CWT system must be maintained. The conflict was resolved by a decision to use electronic detection for recovering CWTs. This electronic CWT sampling is replacing the traditional method of visual sampling and is now required throughout the recovery range of the mass marked stocks.

This was not a trivial decision. The CWT system is the most important stock identification technique used on the West Coast for salmonid research and management (Johnson 1990). Current chinook and coho management relies heavily on the CWT system. The electronic detection equipment is also expensive. It was therefore imperative that the new equipment be highly reliable and that a region-wide transition to this new sampling method be successfully achieved.

The purpose of this paper is to: 1) present the results of recent field tests of electronic detection equipment, 2) discuss the challenges of implementing electronic sampling, and 3) emphasize the importance of CWT sampling at hatcheries.

Results of Equipment Tests

There are two new types of electronic detection equipment: a hand held unit (wand), and a more stationary unit containing a fish passage tube (tube). Prior to 1996, the feasibility and reliability of detecting CWTs with this equipment had not been extensively tested. Since the viability of the CWT system was dependent on the performance of this equipment, several agencies initiated field studies on this equipment. Results of studies conducted by the Northwest Indian Fisheries Commission (NWIFC) are described below:

1996 Coho Tests: In 1996, the year prior to the first return of mass marked coho, the wand and the tube were tested on coho salmon. The primary objectives of the study were to: 1)

achieved during field sampling, and 2) evaluate the feasibility of the
ent sampling situations. Equipment tests were conducted at 20 sites,
tion of tribal CWT sampling situations. These included truck buyers,
ations, processing plants, hatcheries, and spawning grounds.

h detection rates for both types of equipment. The mean detection
ed was 99.3% for the wand and 96.9% for the tube. It was found that
articles on the skin or in their body (e.g. fish that had been in contact
nt, a rusty container, or contained a fishhook) could cause false
e and to a lesser extent with the wand. False detection rates for all
% for the tube and 0.5% for the wand. The rate of false electronic
able with false detection rates that would have been achieved from
se marked but untagged fish) of the same groups: 1.1% for the tube
wand tests.

onducted by Washington Department of Fish and Wildlife (WDFW)
t of Fisheries and Oceans (CDFO) in 1996. Results from all agency
ed in a report to the Pacific Salmon Commission (PSC) (PSC, 1997).
te for the combined agency wand tests was 97%, and the mean
ombined agency tube tests was 98.2%. These rates are believed to
rrent visual detection rates. Conclusions regarding the feasibility of
the following:
e tube appeared limited to high volume sites with level ground
wet fish (e.g., processing plants, buying stations, and hatcheries).
equipment is critical for both detecting tags and avoiding false

no set up time or calibration and would probably be the method of
with low fish numbers and at undeveloped sites.
processing sites (e.g. mechanical lifts and customized tables) should
minate the need to lift and move each fish.
mpling with electronic sampling will involve significant increases
ort

/counter system: In 1998 a new gate & counter unit was available
vs automatic counting and sorting of tagged fish. A field test was
st this equipment prior to the coho season. The specific objective
mine the accuracy of the gate/counter in a commercial fishery
Area 5 sockeye fishery was selected for the availability of fish in
on and a fish size that was similar to coho. Since the fish did not
, a hand held CWT injector was used to place tags in random
oper equipment calibration, sampling of 1,006 sockeye resulted in

ent, untagged fish were processed and both detected and counted correctly by the tube

- There were 8 false positives in the 963 untagged fish processed (0.83% false detection rate)
- All 43 fish with a CWT were detected, counted, and separated correctly

It was concluded that the system, when properly calibrated, has an error rate for counting untagged fish of less than 0.5%. It was also concluded that care must be taken to calibrate the equipment to the idiosyncrasies of each site. This includes adjusting the magnetic sensitivity, setting the gate signal duration to match the velocity of the fish, and maintaining a standard fish passage velocity through the tube.

Testing of the wand on adult chinook: In 1998 we conducted a test of the wand on adult chinook. The purpose of this study was to measure the CWT detection rate of wands used on hatchery returns of chinook salmon tagged with standard length CWTs. This study was conducted jointly with USFWS staff and involved sampling at 4 different hatcheries. A total of 319 marked hatchery chinook were sampled for CWTs with hand held wands. The wands were successful in detecting CWTs in 256 out of 258 tagged chinook (99.2%). Not surprisingly, the two tags that were missed were in larger fish. One of these fish was a five year old fish tagged with the less magnetic older style wire. The results of this limited field test indicate that the wand has good potential for detecting standard length, "new wire", coded-wire tags in adult chinook. The results also led us to recommend the following:

- Further testing of the wand in actual fishery situations to evaluate the detection rate achieved by samplers in the field
- Additional testing on large fish to see if these results can be repeated
- Consult with the wand manufacturer to develop a minimum detection depth standard to ensure that all wands will be capable of detecting single length tags in chinook

Implementation of Electronic Sampling at Hatcheries

As indicated above, the new electronic detection equipment is highly effective in detecting and sorting out CWTs. Besides this change in sampling techniques, the implementation of mass marking and selective fisheries also requires the collection of additional data during mark sampling. Sampled fish are now recorded into one of four categories: 1) tagged and ad-clipped fish, 2) tagged and unclipped fish, 3) untagged and ad-clipped fish, and 4) untagged and unclipped fish. Implementation of electronic sampling for coho began in Washington, Oregon and British Columbia in 1998. This was accompanied by new data collection forms and training workshops to standardize data collection. Although this transition has gone relatively smoothly, hatcheries are still adapting and improving their sampling practices. A few suggestions/recommendations from the first year of sampling include the following:

Maintain high sampling rates: Managers should plan for sufficient personnel to conduct this labor-intensive task, which generally occurs at the busiest time of the year. Hatchery sampling is probably the most cost-effective phase of CWT studies, and the recommended sampling goal at hatcheries remains at 100%. Even if no tagged returns are expected, sampling is useful to gain insight into straying.

Find the most efficient way of collecting the data: The new equipment and data collection requirements will undoubtedly change the way fish are sampled during spawning. We recommend sorting the fish into separate piles: males, females, and jacks; or adults and jacks. Then process each group separately. Marked fish are counted while separating out tagged fish. Use of a tally counter (for the wand) or a pedal operated quad counter (for the tube) may help free up hands.

Make sure the equipment is used correctly: As described above, this equipment has been found to be very accurate. However, the wand must be oriented correctly and the tube must be properly calibrated. Use of this equipment and the new forms will require some additional staff training.

Minimize the fish lifting: Electronic sampling requires that each fish be handled. This can be physically demanding on personnel. High volume sites may want to consider tote lifts and/or staging tables to reduce the physical labor. The idea is to elevate the fish prior to sampling.

Consider electronic detection for steelhead: Unlike salmon, the adipose fin has been used for mass marking hatchery steelhead since 1986. This has limited the ability to conduct CWT studies in this species. In 1996 the USFWS and IDFG conducted a field test on the reliability of the wand and tube detectors to detect CWTs in steelhead (PSC 1997). Detection rates were comparable to that found in coho salmon.

Importance of CWT Sampling at Hatcheries

Sampling of adult returns at hatcheries is the final data collection step in CWT studies. Hatchery recoveries account for approximately 50% of all CWT recoveries. This sampling, combined with accurate hatchery escapement counts, is vital to the success of most all CWT studies. CWT based statistics (i.e. survival rates, harvest rates, and fishery contribution rates) cannot be generated without this sampling. The data acquired by performing this task will have bearing on future decisions concerning both hatchery operations and harvest management.

Getting results from CWT studies is often the most important thing to hatchery managers and biologists. Getting these results commonly involves a period of one to two years after the fish have returned. Processing heads, meshing sampling and recovery data, and reporting data sets does take time. However, some stages are exacerbated by delays in data reporting or difficulties encountered in obtaining and analyzing results. Western Washington tribes are addressing these issues through software programs. Entering and reporting of CWT sampling information is part of the Hat Pro hatchery management software. Sampling data is then transferred electronically, helping to expedite the reporting of this information to the PSMFC database. Results of CWT studies are also readily available to managers through the NWIFC Coded wire tag Retrieval and Analysis System (CRAS) at *www.nwifc.wa.gov*.

Acknowledgements

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References

Johnson, J.K. 1990. Regional overview of coded wire tagging of anadromous salmon and steelhead in North America. American Fisheries Society Symposium 7: 782-816.

Pacific Salmon Commission (PSC). 1997. Ad-hoc Selective Fishery Evaluation Committee, Reliability and Feasibility of Using Electronic Detection For Recovery of Coded Wire Tags In Coho Salmon. Pacific Salmon Commission, 1155 Robson St., Suite 600, Vancouver, B.C. Canada V6E 1B9.

Session V:

Outreach

Session Chair:

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WHY OUTREACH ?

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Abstract

Hatchery outreach is a tremendous tool which can work for you. Many ask the question, "Why do outreach?" In this time of high profile press about salmon, steelhead, and other fish species, it is our job to educate the public about what we are doing to solve the problems we face, not add them. Often times, this involves performing inreach, as well as outreach. If we can make positive community connections, we can make things happen. People need to know how we operate, and the importance of our product; this is where outreach comes in. We need to show our local communities that we are aware of current problems and what the roles of our hatcheries and fish health centers are. Community support and involvement are key factors in a successful outreach program.

The Information and Education (I&E) Specialist in the Columbia River Gorge provides an array of outreach services for the Carson and Spring Creek National Fish Hatcheries in the mid-Columbia River Gorge region. This position has been in existence since 1994. Responsibilities include general outreach and education services for each of the hatcheries, involvement in various local organizations, educational outreach in local school districts, and partnerships with other state, local and federal agencies. It is through these connections and commitments that we have started to gain positive support from our local communities. They view us as a learning opportunity and a source of expertise to which they can turn. The I&E Specialist performs an array of duties which are transferrable to any hatchery station. I have chosen to focus on four main outreach points: hatchery outreach, local organizations, educational outreach, and partnerships.

Hatchery Outreach

Hatchery outreach is many faceted, including everything from hatchery tours to educational displays. Special interest groups request individualized tours frequently. These range from small groups of 4-H students to larger school tours. Spawning is a busy time of year for school tours at fish hatcheries. The I&E Specialist utilizes every opportunity to expose teachers to the idea of a hatchery field trip through teacher fairs, workshops and inservice days. In addition to school tours, the hatcheries encourage public viewing of spawning through local newspaper stories, posted fliers, and large "View Salmon Spawning Today" banners on the highway.

People are usually amazed and extremely interested in viewing salmon spawning and enjoy touring the hatchery.

Each of the hatcheries utilizes a visitor area in which educational and informational exhibits are created and displayed. These are for visitors and group tours that happen to visit during the hatcheries' "off season." Every opportunity is taken to inform the visitor about hatchery practices through photo displays, videos, brochures, or conversation.

Special events are a good way to encourage the public to visit hatcheries. Recently the Carson National Fish Hatchery hosted their first annual Open House, a prime event to showcase hatchery operations. In addition, the first annual Kid's Fishing Day, in September, provided an opportunity for the hatchery to encourage local families to get out and experience fishing first hand. The Spring Creek National Fish Hatchery also hosts an annual Visitor's Weekend each September, attracting hundreds of local and out-of-town visitors. They enjoy watching and learning more about the spawning process. Local Honor Society students volunteer time to assist in the activities, and Northwest Service Academy Americorps Volunteers are recruited to help with hatchery tours.

Of course, there is footwork involved in any special event. Press releases need to be written and distributed, fliers posted, and word spread. Proper publicity is the key to success with any special event.

The I&E Specialist also maintains a website which highlights each of the Columbia River Gorge National Fish Hatcheries, National Wildlife Refuges, and the Lower Columbia River Fish Health Center.

Local Organizations

Mutually beneficial relationships have developed over time between local organizations and state and federal agencies. The I&E Specialist and Project Leaders show support for various local watershed groups by regularly attending meetings. This keeps us informed about what is happening locally, as well as providing us with the opportunity for input and at times, advice to these groups.

Involvement in local organizations includes regular attendance of the Jewett Creek Streamkeepers. This is a cooperative watershed project sponsored by Underwood Conservation District, WA Conservation Commission, WA Dept of Fish and Wildlife, U.S. Fish and Wildlife Service, and the Jewett Creek Streamkeepers.

The I&E Specialist also sits on the Wind River Technical Advisory Committee. This group addresses rising concerns over the condition of natural resources within the Wind River basin. The project uses the concept of watershed management to maintain and enhance the resources of the basin in a manner that is consistent with the goals and objectives of watershed stakeholders.

Other regularly attended monthly and quarterly meetings include the Columbia River Gorge Visitor's Association, Federal Employees Education Consortium, and the Governor's Council on Environmental Education.

Educational Outreach

Much of what we do is educational, but this section deals specifically with schools. Being involved with local schools shows our commitment to education and helps people understand what we are all about. Often times, we think our target audience are the students, but teachers and parent helpers are usually learning right along with the kids. Getting out in the schools allows them to see us in a setting where we are the teachers, providing something that could not be there without hatcheries or fish health centers.

These opportunities include: raising salmon in the classroom in order to better understand salmon life cycles by watching them develop; knowing the importance of hatchery fish and comparing that to the importance of wild fish populations; better understanding external anatomy through an easy but fun activity of fish printing; seeing with their own eyes and hands the internal anatomy of a large tule fall chinook salmon jack in a fish dissection lesson; utilizing instructional aids through our office such as life cycle displays, habitat posters, fish identification posters, fish models, etc.

In addition, we have been able to expand the number of "fin bins" that are available to teachers. These are instructional bins filled with teacher curriculum, puppets, identifications books, dissection models, posters, life stage vials, scale identification mounts, videos, brochures, and much more. Demand for the fin bins is such that they are on a check out system. Teachers are seeking to learn more, in order to pass that on to their students.

Involvement with middle and high school students includes assisting with water quality testing and stream monitoring of local watershed tributaries. The results are reported to local conservation districts. This gives the students a sense of ownership and contribution with data collection in their own watersheds. The I&E Specialist also assists with scheduling field trips and guest lectures for various advanced science classes.

Partnerships

Partnerships are an invaluable tool. As workloads seem to get larger, the people who do the work seems to be shrinking. Partnering with another agency allows participation in an event and the representation of your agency. In the Gorge, I have developed several working partnerships that have allowed the U.S. Fish and Wildlife Service to be represented at events. It is because of these partnerships that the events are able to take place.

Bass Lake Field Day is an annual three day event which educates over 100 students about habitat types and their importance. The I&E Specialist partnered with the U.S. Army Corp of Engineers

Bonneville Lock and Dam rangers and U.S. Forest Service educators to make this event possible.

Oregon Dept of Fish and Wildlife sponsors a huge fishing clinic every year to celebrate National Fishing Week in June. This year, through a partnership with Bonneville Lock and Dam rangers, the I&E Specialist was able to represent the Service in a booth about clean rivers and streams and why they are so important to fish. Over 1400 people attended the event!!

Multiple partnerships are playing a key role in planning for the Spring Creek National Fish Hatchery Centennial Celebration in September 2001. Together with U.S. Army Corps of Engineers, Washington State Parks, Washington Dept of Fish and Wildlife, the Yakama Nation, the Confederated Tribes of Warm Springs, and many other local entities, this event will be a success. Assistance and input from these partners will assure good representation of these various interests and encourage better communication with the visiting public.

With few people working in educational outreach positions, partnering is a must. Partnering is a way to work together and be involved in local and regional events allowing the general public to be informed of agency activities.

Conclusion

It is a very exciting moment to witness the first time a student watches a developing salmon egg hatch, or to see the stares on faces as students watch salmon leaping up a fish ladder. It is a sense of accomplishment to watch students analyze water quality tests, or plant small seedlings on a stream bank; making the connection of habitat needs, environmental concerns, and how that all ties back to our hatcheries and what we are doing there. How can we not think outreach is essential? Or more importantly, how can we think this is *not* a role for us?

GET WET... GET YOUR KIDS IN THE CREEK!

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Abstract

With a little first hand exposure, people can play an important part in reviving our ailing aquatic resources. Watersheds and their health may be understood and appreciated by providing a few tools and a nearby body of water. Aquatic macroinvertebrates and algae can be collected and classified, fish habitat can be surveyed, water tested and riparian vegetation analyzed, measured and planted. Exploring the natural world serves to enlarge perspectives for all visitors, young and old.

Introduction

Why go through the process of organizing even a simple program to get the public in the water for a clearer view of a fish's world? People working closely with the fishery resource primarily do so for countless reasons and some of those are:

1. It's a job.
2. I always liked eating fish.
3. I'm an avid angler and I want to know them better for future fishing trips.
4. Fish are interesting critters, deserve respect and are important in this world.

If you fall into category #3 or #4, then you are probably interested in the survival of this aquatic animal. For that to happen, sensitive species like some salmonids, must have the public involved in their protection. Humans are responsible for habitat reduction and alterations, water quality compromises, and for loving the taste of a species too much. We can conduct hatchery tours and classroom presentations to achieve some appreciation of our fish friends. We can also go beyond and immerse the public into a local body of water.

It is amazing how the view changes by actually donning boots or waders and getting in the creek. There are rocks to pick up with crawling aquatic insects and undercut banks to explore. Vocabulary words like pools, riffles and glides take on new meaning. We can measure oxygen levels and learn that we are not the only creatures that need oxygen to survive. From the water, it is obvious which stream banks have riparian vegetation and which do not. Students can easily surmise what happens to water quality when it rains on eroded banks. Being in and around the water increases knowledge, which leads to greater appreciation and an increase desire to protect the aquatic environment.

Start Simple

You may choose to borrow a few waders and offer the public an adventure in the creek during an open house at your facility. A teacher may request a field trip to your site, leaving the details to you. There are extra water testing kits around and you have them measuring pH, dissolved oxygen and temperature, noting the similarities between people and fish. There are many ways to test the waters of getting your public into the creek for a closer look.

Partners Make Life Easy

Imagine eighty anxious students and their teacher just waiting for you to help them with aquatic education. Staffing on your station is limited, so look around for potential partners. Take the path to other nearby agencies, especially those with a multitude of specialists in various fields. Also look around for private contractors who want their talents known and may help. Water quality testing companies and sometimes even the local health department have savvy personnel just waiting for an opportunity to do something different...like education!

Cases in Point:

The Leavenworth National Fish Hatchery Complex has two "in the creek" programs that are examples of partnerships in action. Winthrop National Fish Hatchery's three year old program is called "Watershed Watchers." Partners include: U.S. Fish & Wildlife Service, U.S. Forest Service, Washington Department of Fish and Wildlife, Methow Natives Nursery (riparian planting), Pacific Watershed Institute, various individual private contractors and the Methow Valley School District.

Leavenworth National Fish Hatchery's Kids in the Creek just celebrated its six year anniversary in '99. The main players include: U.S. Fish & Wildlife Service, U.S. Forest Service, Chelan County Conservation District, Cascade Analytical (water testing), WA Dept. of Fish and Wildlife, and various watershed councils and school districts.

La Crosse Footwear regularly donates hip and chest waders to educational pursuits. We received ten pairs of free waders with just a letter. The name and address of the appropriate contact person is in the Additional Resources section of this paper.

These annual programs would have only remained in the dream stage without partners.

Program Ideas

The following is a list of activities and helpful equipment to give you ideas when planning your program. Since watershed health is directly proportional to fish health in our streams, the inclusion of other non aquatic learning stations is worth considering.

* Aquatic Insects: Identifying and analyzing their functional differences, anatomy and living requirements; picking up rocks or using nets to collect samples; identification with the use of hand lenses, microscopes or magnifying boxes. Other equipment: lasagne pans, tweezers, plastic spoons, recycled plastic containers and an easy insect key or pictures, student worksheets.

* Water Quality: Taking tests usually is limited to equipment and time available. The basics include: pH kit, dissolved oxygen kit, thermometer, something to measure turbidity such as a secchi disk or a turbidimeter, student worksheets.

** Stream Flow: Measuring the flow from different parts of the stream and relating it to water quality. Tools: 100 ft./meter measuring tape, stopwatch, oranges or pine cones for flow measurements, student worksheets.

** Riparian Plants: Studying adaptations and functions and comparing them to upland plants. If conducting transects: 100 ft./meter measuring tape, flagging for study plots, magnifying lenses, student worksheets, field guides optional. For rehabilitation work: plants, shovels, measuring devices, non harmful fertilizer. Wetland transects use the same tools mentioned above.

** Fish Habitat: Looking at fish habitat quality by measuring pools, riffles, glides, substrate type and embeddedness, cover and other indicators. Tools: three 100 ft./meter measuring tapes, three 8' measuring sticks for depth, popcorn to watch flow, student worksheets.

*** Algae: Determining water quality by analyzing the most common forms of algae found in a nearby creek or pond, identifying them and making comparisons. Tools: microscopes with slides and covers, plastic spoons, tweezers, petri dishes, collecting containers, pictures of algae, student worksheets.

* Wildlife Sharing a Fish's World: Investigating wildlife evidence, sightings, and habitat. Tools: Hand lenses, field guides, binoculars.

*** Forest or Single Tree Study: How do forests contribute to clean water? This involves forest ecology or looking closely at tree/shrub/forb adaptations. Tools: hand lenses, field guides, student worksheets.

* Soil: Digging a hole to investigate a cross section of soil and identifying local soils; tools: shovel, soil color charts.

** Watershed: Can be the theme of the day involving its many aspects, including aquatic environments, riparian, forests, soil, animals, humans; can also be about watershed land management situations and decisions.

Role playing different interest groups such as: developers, timber managers, recreationists, agriculturists, etc. and presenting land management plans from each perspective to a group of "county commissioners."

Activity guides abound for working in natural resources with different ages (see Additional Resources section). Most include background information, materials or equipment needed to carry out the activity and student worksheets. When working with classroom teachers, giving them some information to disseminate to students ahead of time will really assist toward understanding some basic concepts before they get to your facility. If you are really ambitious, provide follow-up material to be used after the field trip. This stretches your one day with students to a week or even a semester!

Logistics

If the program is small with one or two of your staff and/or for a short period of time, a schedule will not be necessary. It is of utmost importance when the program approaches a few hours with multiple activities happening simultaneously and extending to three plus specialists working with the public. Everyone will know where to be when and confusion is generally eliminated (although unpredictable things can happen). Contact the author for sample schedules.

Tables, outhouses, hand washing stations, benches, directional signs, garbage cans, first aid kits and drinking water are some items worth considering when planning a larger program. You may want to contact the media, too, so they can see all the good you are doing.

When working with a school, insist they provide chaperones to accompany students. With younger children, the ratio could be as little as one to three. With students older than twelve, one to ten with two student leaders works well. The *Kids in the Creek* curriculum has a sample chaperone/student leader instruction sheet and a form to fill in student and chaperone names ahead of time.

** *Student worksheets available from the* Kids in the Creek *curriculum (see resource section).*
*** *Student worksheets available from the author.*

Just Try It

Numerous options are possible when making a thought of a field experience a reality. Every work station and situation are different. You may have an abundance of marine professionals in your office or you may be surrounded by potential partners that are range technicians. Activities will vary with what the landscape offers. When the Methow River is at high flow, for example, the Winthrop Hatchery will put kids in the ditch to look at algae and aquatic macroinvertebrates. The essential ingredient is a desire on your part to get the public involved in a fish's world for ultimate protection and longevity of our finned friends...

JUST DO IT!

Additional Resources

Farthing P., Hastie B., Weston S., Wolf D. (1992). *The Stream Scene*. Oregon Department of Fish and Wildlife. Portland, Oregon.

Franco, R. (2000). *Kids in the Creek*. U.S. Fish and Wildlife Service. Leavenworth, Washington.

Higgins, D. (1991). *Klamath River Studies for Grades 4-6*. Klamath River Educational Program. McKinleyville, California.

Murdoch, T., O'Laughlin, K., Cheo, M.. (1994). *The Streamkeeper's Field Guide*. Adopt-A-Stream Foundation. Everett, Washington.

Lynn, B. (1988). *Discover Wetlands*. Washington Department of Ecology. Olympia, Washington.

Smith, J. La Crosse Footwear, Inc., P.0. Box 1328, La Crosse, WI 54602

USDA Forest Service. (1993). *Investigating Your Environment.*. Portland, Oregon: Author.

PRESERVING OUR RICH FISH CULTURE HERITAGE FOR FUTURE GENERATIONS - D.C. BOOTH HISTORIC NATIONAL FISH HATCHERY

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Abstract

Our Nation has a rich fish management heritage dating back into the early 1800's. In our profession we have been slow to realize the importance of preserving cultural resources relating to fish culture. This presentation will review the history of fish management and culture, provide a status report on the USFWS efforts at D.C. Booth Historic National Fish Hatchery, and discuss developing exhibits and outreach efforts.

MEDIA....
FRIEND OR FOE?
TIPS AND TRICKS FOR SUCCESSFUL MEDIA RELATIONS

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The news media has become one of the most powerful forces in this society. No other industry possesses more power over the way people think, feel, believe and live than the media. It has the power to build mountains or crash down cities. It can be full of hope or full of disaster. The media offers abundant opportunities for fisheries professionals, as ourselves, to meet our work objectives in creative, innovative, engaging and educational ways.

Working with the media in our local communities can and does build relationships and resources that are mutually beneficial at all levels. Don't be shy. IF correctly handled, the sharing of accurate, concisely delivered information to a local media source has the potential to gain invaluable positive results for our agency, support for our individual field station programs and credibility for current and future projects.

There are many resources within each of our government agencies available for media advice. It is important to establish a rapport with your agency media and outreach specialists. They can facilitate media training, share and provide experience and strategic direction in working with the media and come to your rescue when media stress gets over your head. It is the role of agency public and external affairs offices to maintain healthy working relationships with all members of the media in their local, state, regional and national communities. They serve as excellent advisors and liaison representatives when issues become larger and bigger in scope than most small field stations or hatcheries can handle. There are only a handful of hatchery programs in the northwest that provide information and education outreach specialists that are trained and possess the skill and ability to work effectively with the media.

If you have not yet had the pleasure of being put on the spot in front of a television camera, or under the pressure of writing a press release fifteen minutes before the deadline, or getting taped live on a radio listener call-in talk show about your agency's political views of the salmon issue, or getting ambushed by unannounced reporters while you're leading a hatchery tour for the national board of the Sierra Club, well, you just haven't experienced some of the best (or worst) memorable challenges you'll face in your entire career.

To help you through these moments of terror, I highly recommend purchasing one of the best books on the entire subject, **Winning With the News Media**, by Clarence Jones, a good informative read for every fish hatchery manager. Some of Jones' best tips and tricks are currently being taught in various government agency and private industry media training sessions. The simple basics of media relations are spelled out in his chapter called "Strategy". Here are his "Ten Commandments of Media Relations":

1. Be open and cooperative.
2. Personalize you and your organization..
3. Develop media contacts.
4. Take good stories to the media.
5. Respond quickly.
6. Never say, "no comment".
7. It's OK to say, "I don't know" (But, I'll find out)
8. If you screw up, confess and repent.
9. Use the big dump.
10. Prepare, prepare, prepare.

As a public information and education specialist, I have learned many of these lessons by trial and error. I can honestly say I learn a new tidbit of tact from every media experience I encounter. Here are some basic common sense applications I would like to add to Jones' list:

1. Be courteous.
2. Stay focused and on track.
3. Know the subject–or definitely get someone who does.
4. At all times, remember who your listener or audience is.
5. Be personable and speak in a language that makes sense. No acronyms!!.
6. Make personal visits to your local newspaper office, radio station, television station on a regular basis. Get to know your local editor and assigned reporters to your subject area.
7. Get to know your local visitor center and chamber of commerce information people.
8. Sip on a latte among your community business leaders in the local coffee shop on occasion. Some of the most important business and work issues can be discussed in these settings.
9. Stay trained. Take another media course even when you think you could teach it.
10. Utilize the expert media specialists in your agency or organization.
11. Be accountable.
12. Keep copies of everything. Create a news clipping file.
13. Remember that good reporters need you. You, too, can become a valuable contact for them.
14. Don't waste time or attention. Make every contact count.
15. Do your homework and make absolutely certain you are truly representing yourself, your boss, your agency and its mission.
16. Never say "no comment". It is assumed you are hiding something.

17. Be real. In a media-driven society, the reporter's perception can become reality.
18. Rehearse every question (and more!) you think you may have to cover in an interview. Run the answers by your boss.
19. Be honest. Lies never die on tape. You can be put on rewind over and over and there's no way around it.
20. Don't be wishy-washy. Remain steadfast in your views and statements.

Knowing what message you set out to set straight keeps your direction clear. What do you want the media to do for you? In many cases, the media may be the only way to reach your communication goals. To be successful with the media, each of us must understand how reporters and editors work. By maintaining good solid relationships with your media contacts you will benefit in more ways than you realize. If your local reporter views you as his ally and knows he will get a truthful story from you on a certain topic, you will find that you can influence the system more than you realize. You can win with the media and the media can win with you. This winning may be what it takes to change people's behavior in a positive way about natural resource conservation. We can make a difference.

MIGRATION GOLF:
LINKS TO THE SEA

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Abstract

Welcome to Migration Golf. Take the round trip journey from the safety of the hatchery to the Pacific Ocean and back. Start with a school of 100 young salmon smolts and see how many you can get safely back to the hatchery as spawning adults. Lose one fish for each stroke and remember to mark off 10 fish when you get trapped in a hazard (all holes) along the way. The player that returns the most adults to the hatchery is the winner.

Discussion

Migration Golf, Links to The Sea, was the brain child of Bill Thorson, Manager, Carson National Fish Hatchery. Bill wanted to tell a hatchery Pacific Salmon life history story in a way that would be educational, interesting, entertaining, and would further show that there are a variety of factors affecting salmon survival outside hatchery environments and that the decline of salmon is the result of the combined effects of many different variables. It is important that fingers not be pointed or judgements made. Bill came up with the idea of a miniature golf course to simulate the migration of hatchery reared salmon from the hatchery to the Pacific Ocean and back, with as few losses as possible. One fish would be assessed or lost for each stroke taken and ten deducted each time a ball fell into a hazard. After overcoming the skepticism of the crew, Bill approached Greg Pratschner, Manager of Leavenworth National Fish Hatchery Complex with the idea. Greg bought into it right off and agreed to partner on the project by providing funds for construction materials. Many thanks to Greg, for without his participation, the course would have remained a pipe dream.

The portable miniature golf course became the ideal tool to tell the story. The target audience for this story would be elementary children, specifically fourth graders. The course itself was designed with portability and size constraints, so it could be moved to other locations with relative ease and also for broad exposure. A trailer was purchased to store the course in and transport it. Jeff Blaisdell, Carson National Fish Hatchery's maintenance worker, constructed the course with design help and specifications from Bill. Before long, one hole (or section) after another started to take shape. Soon everyone at the hatchery had supplied input or help in the course's completion. The finished course consists of six sections.

The first section (1a) is the hatchery. Salmon raised in hatcheries are protected from many of the predators found in streams and do not need to compete for limited food and space like wild fish. This does not mean that life in the hatchery is easy. Fish eating ducks, mink and otters are examples of predators attracted to hatcheries. Disease is another cause of death for hatchery fish. But, by practicing good fish culture methods, losses to fish disease can be minimized or avoided all together. So see if you can begin your migration to the Pacific Ocean without being eaten by a duck or getting sick from fish bacteria or viruses.

Section (1b) The stream. Salmon released from hatcheries must learn quickly to avoid attacks by Northern pike minnow, walleye, sea gulls, terns and a myriad of other predators as they migrate to the Pacific Ocean. Avoid the predators if you can.

Section (2) Dams
Migrating salmon juveniles have three ways to get past the Columbia River dams. Going over the dams through the spill gates is the method least harmful to the fish, because salmon carried over dams by spilled water avoid the turbines. Fish bypass systems use large screens to guide migrating fish to pipes around the dams. The third way past dams are to go through the turbines. Some fish are injured or disoriented as they pass through the turbines making them easier targets for the predators waiting below the dams. Which route will you take?

Section (3) Ocean Conditions
Recent El niño (a weather pattern) events have caused ocean temperatures to rise several degrees creating warmer ocean waters where salmon live. The warmer water greatly decreases the amount of food available for salmon and lets predatory fish normally found in the southern part of the ocean move into areas used by young salmon. If you are lucky, you will find La Niña and have favorable ocean conditions. If not, well it's been good knowing you!

Section (4) Dams
Adult Salmon returning to spawn in the streams where they were born use fish ladders to get past the Columbia River dams to complete their migration. The fish ladders can be difficult to find especially in high water years. Salmon sometimes make their way around dams only to fall back and have to try again. How many times will you need?

Section (5) Homing
Salmon returning to spawning grounds in the Columbia Basin are harvested by Native Americans and sport fisher persons. See if you can escape capture in the Indian gill nets and dodge the sport fisher persons. If you miss the mouth of your home stream, as salmon sometimes do, you will have to backtrack to find it. Make your way into the hatchery adult holding pond and your migration is complete.

The miniature golf course was designed as an educational tool to tell the story of hatchery Pacific Salmon. The course tells the story as you play it. Having fun while learning seems to make people learn the fate of hatchery salmon all the better. As you lose fish along the way, it gives you a real appreciation for the few fish that do survive to spawn. The course has been a huge success at several events. The trial run was at Carson Elementary School for fall carnival. Here it was estimated more than three hundred children and adults played. This is where we learned it's best to have a guide at each section to answer questions and explain the section. Next the course was set up for Carson National Fish Hatchery Open House, even though the weather was terrible, almost all visitors played. The course was also set up in Portland at the Regional Office. Here BPA and Interior employees played, and the course received rave reviews. The course was then transported to Winthrop National Fish Hatchery for a children's fishing event. Bill said, "the course was a huge success there." We then set the course up for Carson National Fish Hatchery's Children's Fishing Day. Another two hundred or more people played it. The largest event so far was the Wenatchee River Salmon Festival at Leavenworth National Fish Hatchery. Here an estimated one thousand people of all ages played and played.

We realized people were learning more about the tedious life a salmon lives by their comments after completing the course like, "I didn't realize what all they go through" or "I only had a couple of fish left" or "can I start over all my fish are dead." Most people come away with a new understanding about factors that control salmon survival. Some people just like to play the game and play it over and over.

One interesting thought is that once the salmon leave the hatchery, they are subject to the same factors wild fish are, so a wild fish course could easily be developed showing the fishes life in its home stream before it out migrates with the selection factors at work there.

IDEAS FOR DEVELOPING "FIN BIN" EDUCATION OUTREACH ACTIVITIES

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Abstract

As a graduate student at the University of Idaho seeking a Masters in Education, I spend many hours in campus classrooms and in front of my computer wondering how to "plug-in" my (very) specific anadromous fish content area into lesson plans chiefly designed for the average elementary and middle school curriculum. While my fellow teaching and education scholars are adapting content areas such as math, history, and English to fit readily within lessons aimed at improving reading skills or vocabulary, I wonder to myself, "How can I make fish relevant here?" "Will fish really matter to the student if they follow through on this lesson?" "Can learning about anadromous fish help a child with their vocabulary or reading?" All of these questions would leave my head literally swimming with fish!

Discussion

The Fin Bin was originally developed in 1994 by Rachel Little at Leavenworth National Fish Hatchery. Later, Rebeca Franco continued the project by writing Fin Bin curriculum. Most recently, Judy Maule wrote another grant to produce additional Fin Bins for U.S. Fish and Wildlife Service hatcheries in the Pacific Region. Used today by many hatcheries for education outreach, the Fin Bin contains an assortment of fisheries-related tools for learning in the classroom. Items such as models, books, videos, puppets, and posters provide hands-on opportunities for students to learn about fish. The only problem is that the newest Fin Bins did not have many lesson plans, or what I call "recipes for learning." These "recipes for learning" are basically what a teacher will look for in order to implement Fin Bin tools into actual educational activities. With all this in mind, I designed lesson plans that integrate the various types of "multiple intelligences," or basic "learning styles" of students. "Learning style" pertains to the different ways that pupils comprehend information on an individual level—such as linguistically, spatially (visual thinking), logically (math/critical thinking), musically, intrapersonally (inner thinking), interpersonally (people thinking), or kinesthetically (body language).

For hatchery managers who don't have the time or staff to work on developing "learning recipes" for the Fin Bin, I recommend recruiting outside helping hands. This can be relatively simple. There are many university and community college student volunteers, or interns, in natural resources and education training. Some are seeking teacher certification in Earth

Science, Biology, and other content areas that are clearly linked to fishery resources. Some students in content areas such as Social Studies and Economics may also be interested in environmental education. Many are seeking outside work study projects to earn extra class credit, with the approval of a course professor. Another option may be to seek out high school students who are in "gifted and talented" programs and wish to do assignments that challenge their present school curriculum. Other resources for outside help are young people and former teachers from your local community who are involved in natural resource education.

There are several Fin Bin lesson plans that I have developed to get you started. You may wonder how I came up with these ideas. Many came from "plugging-in" what I know about anadromous fish into teachers' lesson plans that were assigned to me by my U of I professors. Some came from the "top of my head," and others came from revamping old information entombed in the farthest reaches of Susan Sawyer's dusty bookshelf. Here are the current "recipes for learning" intended for elementary, middle school, and secondary students:

- Salmonid Life Cycle Poster and Play (presenting a salmonid life cycle pictorially or by enactment)
- Find Your Salmonid Water Address (conducting a salmonid migration simulation through a sense of smell)
- Magic Square Games (learning fish-related vocabulary while having fun solving a number puzzle)
    - –Anadromous Fish Magic Square Game
    - –Fish Anatomy Magic Square Game
    - –Fish Hazards Magic Square Game

Of course, to specify a lesson to concur with elementary, middle school, or secondary standards depends largely on your local school district. Other lesson plans I will be working on in the near future are:

- Crossword Puzzles
- Coloring Activities for Elementary Students
- Current Events and Fisheries Issues
- Are We Fish-Friendly? / Fish Impact Self-Assessment
- Internal / External Fish Anatomy Origami / Paper Folding

In conclusion, I would like to convey that the cost of implementing lesson plans for the Fin Bin, or other similar educational tools, is minimal—a little footwork, creativity, time, and a certain amount of enthusiasm. If you have the least bit of doubt about the learning quality of a lesson plan, take it to a teacher for evaluation. Most would be happy to help out in exchange for a classroom visit or hatchery tour. I would also like to express that these generic Fin Bin "recipes for learning" will accommodate the learning styles of most elementary and middle school students, and are ready-to-go as adaptable learning tools. Some pupils *(and that means all of us because we are all learning all of the time)* may use a combination of learning styles, and some may use primarily one to retain most of the knowledge we are exposed to—THAT concept makes us all unique.

Keep in mind that there are education outreach people such as myself to call upon that will be more than willing to share existing lesson plans or ideas. The trick is to not loose sight of the big picture—we are all in the fish business together, whether it be as a manager, fish culturist, or outreach specialist. Fisheries education is critical to fostering public support of our programs in the coming century.

Abstracts for Posters

Poster Coordinator:

Dave Owsley
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EFFECTS OF RATION LEVEL ON SELECTED PARAMETERS OF DISEASE RESISTANCE IN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

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Abstract

There is evidence that many of the specific and nonspecific host defenses of salmonids and other fishes are affected by specific dietary components. As part of a larger study funded by the Bonneville Power Administration to measure the effects of hatchery practices on physiological indices of captive salmonid broodstock, we developed a panel of hematological and immunological assays to monitor various indicators of the health of a fish's immune system. Analyses included measurements of hematocrit, leukocrit, differential leukocyte counts, plasma protein concentration, complement activity, and lysozyme activity. To monitor the non-specific cellular immune functions, leukocytes from the anterior kidney were analyzed to quantify the percentage of macrophages that would actively phagocytize bacteria, and the relative production of two bactericidal components by those cells, myeloperoxidase and the superoxide anion. We measured the effects of ration level (and consequently growth rate) on those indicators in chinook salmon. Groups of chinook salmon fingerlings were reared at 8 °C-12 °C and fed a diet containing 54% protein and 7.4% lipid. Ration-level groups were 100% (fed to satiation), and 64% and 40% of the satiation quantity. Fish from each ration-level group were sampled for testing 27, 37, and 51 weeks after initiation of feeding with the experimental diets. As expected, during each sampling period fish in the 40% and 64% ration-level groups were smaller with regard to length and weight compared to fish in the 100% ration-level group ($p \leq 0.05$). Overall, there were no differences among the ration-level groups for the hematological analyses, except that leukocrit and plasma protein concentrations were higher in fish from the 100% ration-level group compared to levels in fish from the two other ration-level groups. The most interesting differences, however, were detected in the activity of the macrophages. The proportion of macrophages present in the kidney that would phagocytize bacteria was greater among fish from the group fed the 40% ration compared with fish from the group fed the 100% ration ($p \leq 0.05$). An effect of different rations on the production of myeloperoxidase by the phagocytic cells is also suggested by a trend toward more activity in phagocytic cells from fish fed the lowest ration. The increase in the percentage of phagocytic macrophages may indicate a state of greater activation in macrophages from fish reared at a non-satiating diet level. Conversely, the greater percentage of phagocytic cells may reflect the inability of the mature macrophages to emigrate from the hematopoietic tissues of the anterior kidney. This second explanation may be supported by the increase in circulating leukocytes in the fish reared at the higher ration levels. These results may be important to the fish culturist because macrophages are part of a salmonid's first lines of defense against infection by pathogenic microorganisms.

COLUMBIA RIVER FISH MARKING PROGRAM

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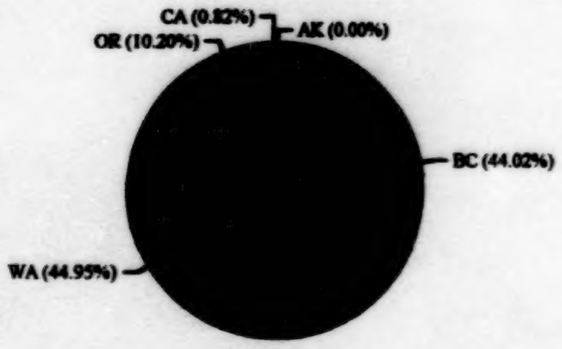
Abstract

Staff from the Columbia River Fisheries Program Office and contracted marking crews mark between six and ten million fish each year in the Columbia River basin. The types of marks used include fin clips, coded-wire tags, and PIT tags. The number of fish tagged at each hatchery varies with the objectives of the tagging study.

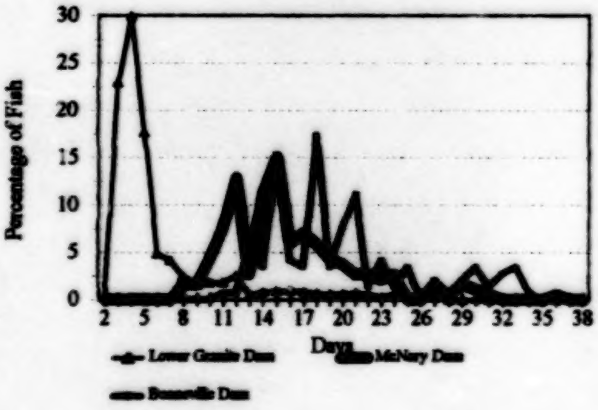
Coded-wire tags make it possible to recover information about where and when a group of fish are caught or return to the hatchery. Microscopic codes are etched into the wire when it is manufactured. The coded-wire is cut into one mm lengths and injected into the snouts of the fingerlings. Recovered tags can be decoded by technicians to provide information on the origin and age of the fish. The data can be used to estimate a number of statistics important to fishery managers, including overall survival, fishery harvest rates, and ocean distribution of the stock.

PIT tags are used to monitor the movement, passage and survival of migrating smolts and adult salmon and steelhead. The advantage of PIT tags is that they can be read or decoded without killing the fish. Information from PIT tags is used to manage flow and spill at dams; monitor hatchery and natural production programs; and evaluate predation, transportation, bypass, and survival.

Total Ocean Recoveries
Spring Creek NFH
Fall Chinook Salmon



Dworshak NFH Summer Steelhead - 1998
Outmigrant Travel Time



EVALUATION OF AMERICAN WHITE PELICANS AND BALD EAGLES AS VECTORS OF *MYXOBOLUS CEREBRALIS*

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Introduction

Whirling disease is caused by a parasite (*Myxobolus cerebralis*) that invades cartilage of young developing fish, encysting and becoming encased in bone as the fish develops. The parasite can move down stream during the free-swimming, triactinomyxon stage, or up-stream when an infected fish swims up-stream and dies. Transmission between watersheds can occur when the parasite is moved by man or animal, providing both the salmonid and oligochaete hosts are present in the receiving water. Determining the methods of transmission of the parasite, both within states and between states, is important to understanding distribution of the parasite.

Taylor and Lott (1978) demonstrated the possibility of bird transmission of *M. cerebralis* to previously uncontaminated waters. Black-crowned night herons (*Nycticorax nycticorax*) and mallard ducks (*Anas platyrhynchos*) were fed trout infected with *M. cerebralis*. The feces of the birds were placed in mud bottom troughs along with uninfected trout. The young trout eventually became infected indicating that spores survived the digestive tract of the two species of birds. The possibility of birds transmitting the spores around as they travel was demonstrated by Taylor and Lott (1978), but the overall importance of this mode of transmission is unknown. The length of time required by the bird to excrete all the spores might reflect the importance of this mode of transmission in the overall spread of the parasite. For example, if spores have all passed through the birds in one day, the spread due to one meal may not be that significant. If the spores are voided by the birds over a longer period, transmission of the parasite could take place over much greater distances.

Range of American white pelicans is restricted to North America and nesting occurs primarily in the northern Great Plains. Pelicans also nest in smaller numbers in large lakes in western Canadian forests and marshes in the inter-mountain region of the U.S. Breeding habitat is associated with both lentic and lotic systems with shallow waters and high fish populations. American white pelicans nest colonially, mostly on islands that are inaccessible to terrestrial predators. American white pelicans are highly migratory, wintering in southern California, coastal mainland Mexico, the Gulf Coast of the U.S. and Mexico, and Florida. American white pelicans inhabit virtually every state west of the 100th meridian at some time during their annual cycle (Evans and Knopf 1993).

American white pelicans possess long pointed wings which are characteristic of highly migratory species (Rüppel 1977). In fact, migration routes and recoveries of American white pelicans banded in Yellowstone National Park cross virtually every major watershed in the western U.S. (Diem and Condon 1967). However, daily mechanics and rate of movement have not been recorded. If daily ranging behavior in summer (≥105 km in one day) is indicative of capability during migration, American white pelicans may move in excess of 200 km per day during migration, potentially transporting agents of disease over large distances in one seasonal migration.

American white pelicans are opportunistic feeders, quickly cuing on temporal availability of food (Knopf and Kennedy 1980). Strictly piscivorous (Brouwer et al. 1994), American white pelicans feed on fishes usually 10 to 11 cm long, but will take individual fish up to 68 cm in length (Evans and Knopf 1993). Species commonly taken are carp (*Cyprinus carpio*) and creek chubs (*Semotilus atromaculatus*)(Knopf and Kennedy 1981) within 1 m of the surface, but crappie (*Pomoxis* spp.), suckers (*Catastomus* spp.), yellow perch (*Perca flavescens*), bullhead and catfish (*Ictalarus* spp.) are also taken (Wander 1981). Feeding method involves scooping fish dip-net fashion in shallow water (<100 cm), often after driving or surrounding fish by cooperative herding or occasional by pirating other piscivorous birds (Anderson 1991). Feeding activity occurs most frequently at night (O'Malley and Evans 1984, McMahon and Evans 1992), usually between 0001 and 0300 hrs with daytime hours spent loafing (O'Malley and Evans 1984). Foraging flights may extend up to 52 km from breeding areas in one day (Trottier et. al. 1980) and pelicans were found up to 308 km from the nesting colony in North Dakota (Lingle and Sloan 1980).

By the mid 1970's American white pelicans were considered to be declining range wide due to insecticides, shooting, and disturbance at breeding colonies (Udvardy 1977). By 1979, the U.S. population had declined nearly 9% (Sloan 1982). Coincident declines were noted in Montana, with populations decreasing between 51% and 75% from 1964 to 1972, allegedly a result of drastic fluctuations in water level (Sloan 1982). However, more widespread declines were attributed to the effects of organochlorine pesticides on egg mortality (Lies and Behle 1966, Vermeer 1970). Populations appeared to rebound in the early 1980's (Roney 1982), reaching stability in the mid 1980's with only local fluctuations (Roney 1984). Population estimate in 1985 was 109,110 breeding birds, 59% in Canada and 41% in the U.S. (Siddle et al. 1985). In the 1990's, although no census data exist, populations appear to have increased dramatically. Where few American white pelicans were seen in the 1970's and 1980's in Montana (Missouri River and impoundments and other rivers in southwestern Montana), the species is now common and occasionally nuisance (e.g., Koonz 1981), especially as perceived by anglers (authors, pers. obs.).

Range of the bald eagle is restricted to North America. Historical distribution included every U.S. state and Canadian province plus portions of northern and eastern Mexico (Brown 1976). During the 1960's, when populations were depressed through the effects of the organochlorine pesticide DDT and its metabolites, breeding range shrank to include only remote, forested portions of the continent, mostly in Canada (Stalmaster 1987). Subsequent to the ban on use of DDT in the U.S. in 1973, bald eagle populations rebounded throughout their range (Grier 1982).

Most bald eagle nest sites are associated with large rivers, lakes, impoundments and coniferous and deciduous forests throughout the U.S. and Canada. Pairs nesting north of the Canadian border generally migrate to wintering areas in the Continental U.S. and Mexico. Bald eagles from Alaska generally move toward the coast of the state or at most to the northern coast of British Columbia for winter (Stalmaster 1987).

Creatures of aquatic environments, bald eagles occupy riparian or lacustrine habitat almost exclusively during the breeding season, but occasionally exploit upland areas for food and roost sites, especially during winter. Nest sites are most commonly distributed around the periphery of lakes and reservoirs $\geq$32.4 ha. in area and linearly along forested corridors of major rivers, usually within 1.6 km of shore (Wright and Escano 1986, Jensen 1988). Nest sites are usually as close to maximum foraging opportunities as possible (Harmata and Oakleaf 1992). Density of breeding pairs is highest along sinuous and braided sections of rivers and eutrophic lakes (Stalmaster 1987, Dzus and Gerrard 1993). Some pairs include both rivers and lakes in their home range. Bald eagles often forage year round near riffles, runs, and pools of rivers. On lakes and reservoirs, bald eagles, like American white pelicans, use shallow areas, associated wetlands, littoral zones with gently sloping shoreline and confluences of peripheral streams (Fielder and Starkey 1986, Caton et al. 1992). Estimates of home range size in the breeding season vary from 2 km^2 (Mattson 1974) to 234 km^2 (Yates 1989) but home ranges on rivers are more adequately represented linearly (length of river included) while minimum convex polygon (Mohr 1947) is more descriptive of home ranges on lakes. Accordingly, bald eagles incorporating only rivers in their range in Arizona and the Greater Yellowstone Ecosystem averaged 19 km and 7.6 km of river, respectively (Hunt et al. 1992, Harmata and Oakleaf 1992). Eagles incorporating only lakes in their home range had an average of 4 to 7 km^2 range in Saskatchewan (Gerrard et al. 1992) and 71.6 km^2 in Wyoming (Harmata and Oakleaf 1992).

Most young bald eagles leave natal breeding areas their first autumn, as do adults north of the 48th parallel. Bald eagles traveling to wintering areas scattered throughout the U.S. moved ≤50 km/day (Harmata et al. 1985, Hunt et al. 1992) but up 250 km/day in spring (Harmata 1984). Migrant bald eagles often follow spring spawning runs of local fishes, both altitudinally and latitudinally. During the remainder of summer, immature movements are often concentrated on larger lakes in their range. Bald eagle winter habitat is mostly associated with areas of ice-free water where fishes are available and/or waterfowl congregate (Snow 1973, Stalmaster 1987). Concentrations of vernal migrant eagles are small (<30) and dispersed and usually associated with waterfowl or small mammal concentrations because aquatic systems are usually frozen, limiting the availability of fishes. Food habits are eclectic, reflecting the opportunistic behavior of the species but fishes are clearly preferred (Snow 1973, Todd et al. 1982, Stalmaster 1987, Watson et al. 1991, Mersmann et al. 1992).

Other pathways of transmission may be involved in the spread of *M. cerebralis*, but only by evaluating each of these pathways can a comprehensive understanding of the of the spread of the parasite be developed. The rate at which birds pass excreta containing *M. cerebralis* spores may have implications on mode, distance, and distribution of the spread of whirling disease throught the western U.S. The objective of this study was to determine the passage time of a meal in the gastro-intestinal tract of piscivorous birds common to Montana waters. American white pelicans (*Pelecanus erythrorhynchos*) and bald eagles (*Haliaeetus leucocephalus*), two large (>4 kg) piscivorous birds frequently seen in western waterways, were chosen for study.

Methods

Two bald eagles and 4 white pelicans were evaluated. Bald eagles were captive birds used for educational and research purposes, were maintained at separate locations, and restrained with traditional falconry methods. Both were adult females. Pelicans were captured from a wild flock on Ennis lake, Madison County, Montana using a cannon net. Pelicans were restrained in individual cages at night. Cage dimensions were: floor, 122 x 122 cm; walls 122 x 117 cm; door- 107 x 122 cm. Floor was a 44 x 19 mm plastic coated, rigid steel mesh that allowed fecal material to drop through to a steel collection tray below. Walls and roof were a 5 cm diagonal, poly-netting. Because pelicans are gregarious and facilitate each other's behavior, cages were clustered to maintain close visual and auditory contact. During the day pelicans were at large for exercise in a barn with a fine beach sand floor. A variety of perches were available as were 3 large children's pools for swimming and hydration.

No *M. cerebralis* spores were used in this study due to containment concerns. Trace minerals were used as indicators of rate of passage, because concentrations can be easily and accurately measured. Two groups of captively raised rainbow trout (*Oncorhynchus mykiss*) were reared as food for the birds. The first group was fed a standard fish-meal based diet and were designated as "unmarked " fish. The other group was designated " marked" fish and received a diet containing krill meal which was high in strontium (Sr), Yttrium (Yt), and chromium (Cr) mineral markers. Sr was selected as a marker because it deposits directly in bone of receipient fish. Thus, transit time of Sr through birds should be similar to *M. cerebralis* spores. Yt and Cr were chosen because they are commonly used for nutrition studies to determine nutrient digestibility or rate of passage. Yt and Cr were fed to marked trout in the oxide form and were indigestible, and thus remained in the intestinal tract of the trout. Sr, Yt, and Cr were analyzed in bald eagle fecal material but Sr and Yt were analyzed in pelican fecal material.

Pelicans were given a 30 day acclimation period to acclimate to the captive environment and facilitate normal metabolism prior to intiation of experimental feeding. Because eagle had been in captivity >3 years, no acclimation period was necessary. Unmarked fish were fed to eagles and pelicans for 3 days prior to feeding marked fish. Unmarked fish were then provided for 14 days. Eagles were fed to satiation once daily and excess food removed. Pelicans were fed daily in the evening after entering cages. Fecal material was collected from the substrate beneath perches (formica or plastic tarpaulin) bagged, dated, and identified by individual each morning, then substrate cleaned completely. Fecal material was analyzed for Cr, Yt and Sr using both Atomic Absorption Spectrophotometry (AAS) and Inductively-Coupled Plasma Spectrophotometry (ICP). Time from introduction of marked fish to maximum concentration of mineral markers in fecal material was determined as was the time from introduction of unmarked fish until minimum levels of mineral makers. These times were considered passage rates.

Results and Disscusion

Mean time to maximum level of mineral markers in bald eagle fecal material averaged 2.3 days after introduction of marked fish (Table 1). Mean time to reach minimum levels of mineral markers after introduction of unmarked fish was slightly longer (2.8 days). Times to maximum and minimum levels were not different among minerals and eagles $(F_s = 1.22, P = 0.36)$. Time to maximum level of Sr in pelican fecal material after introduction of marked fish was not different between AAS and ICP analyses (Table 2). Mean time to maximum level of mineral markers in pelican fecal material averaged 2.3 days after introduction of marked fish. Unlike eagles, mean time to reach minimum levels of mineral markers after introduction of unmarked fish was slightly shorter (2.25 days). Times to maximum and minimum levels were not different among minerals and pelicans $(F_s = 1.00, P = 0.43)$.

Results suggest that both species could excrete *M. cerebralis* spores from eating an infected fish over a 2-3 day period . Condition affects passage rate of food and birds not food stressed would tend to decrease transit time of digesta. Eagles used in this study were fed to excess each day and 3 of the 4 pelicans gained weight during the study, indicating subjects were in good condition. Thus estimates of period over which eagles and pelicans may expel *M. cerebralis* spores are conservative, and could be longer in wild birds. However, if infected fish are eaten just prior to extensive ranging flights (i.e., migration) coincident energetic stress could transport agents of whirling disease hundreds of miles from origin.

Because many factors contribute to incidence of whirling disease, (oligochaete hosts, exposure to triactinomyxons, and other unknowns), translocation of spores alone will not necessarily cause disease. Food habits of an avian species in a given watershed, food passage rate and migration strategies should be considered when evaluating the overall role of birds as vectors of fish diseases. Due to the number of different species of birds that may transport spores of *M. cerebralis* spores, migration distances and speeds of those birds, and rate of passage of digesta, attempts to control the spread of the parasite by controlling bird populations would be ill-advised, probably impossible, and most likely detrimental to the overall health of the ecosystem. These data indicate another natural mechanism for transmission of the parasite that should be considered when management plans are developed.

Table 1. Hours to maximum[1] and minimum[2] fecal marker level[3] of bald eagles fed marked and unmarked trout.

	Eagle 1		Eagle 2	
Mineral	Max.	Min.	Max.	Min
Strontium	48	72	48	72
Yttrium	48	72	72	48
Chromium	72	72	48	72
Mean	56	72	56	64
Mean by bird	64		60	
Eagle mean	62 hours			

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[1] after consumption of marked fish for maximum fecal level of mineral

[2] after consumption of unmarked fish for minimum fecal level of mineral

[3] Inductively-Coupled Plasma Photometer, National Marine Fisheries Service, Seattle, WA.

Table 2. Hours to maximum[1] and minimum[2] fecal marker level of pelicans and fed marked and unmarked trout.

Mineral marker	Strontium				Yttrium	
Analysis Method	AA[3]		ICP[4]		ICP[4]	
Pelican	Max.[1]	Min.[2]	Max[1]	Min[2]	Max.[1]	Min.[2]
1	48	48	48	48	48	48
2	24	72	48	72	48	48
3	48	72	48	72	72	48
4	72	48	72	48	72	48
Mean	48	60	54	60	60	48
Method mean	54		57		54	
Mineral mean	55.5				54	
Pelican mean				54.7		

[1] hours after consumption of marked fish for maximum fecal level of mineral

[2] after consumption of unmarked fish for minimum fecal level of mineral

[3] Atomic Absorption Spectrometer, ACT Labs, Inc., Fort Collins, CO

[4] Inductively-Coupled Plasma Photometer, National Marine Fisheries Service, Seattle, WA.

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References

Anderson, J. G. T. 1991. Foraging behavior of the American white pelican (*Pelicanus erythrorhynchos*) in western Nevada. Colonial Waterbirds 14(2):166-172.

Brown, L. H. 1977. Eagles of the world. Universe Books, New York. 224 pp.

Brouwer, K., B. Hiddinga, and C. A. King. 1994. Management and breeding of pelicans, Pelecanus spp in ca
International Zoo Yb. 33:24-39.

Caton, E., M. Donofrio and B.R. McClelland. 1989. Spring migration of a juvenile bald eagle from Glacier N
Park: Habitat use and management recommendations for the Missouri River. U.S. Dept. Int., Nat. Par
Res. Div. Glacier Nat. Park, W. Glacier, MT. 13 pp.

Diem, K. L. and D. D. Condon. 1967. Banding studies of water birds on the Molly Islands Yellowstone Lake, Wyoming. Yellowstone Library and Museum Association. Yellowstone National Park, Wyoming.

Dzus, E. H. and J. M. Gerrard. 1993. Factors influencing bald eagle densities in northcentral Saskatchewan. Journal of Wildlife Management. 57:771-778.

Evans, R. M., and F. L. Knopf. 1993. American white pelican (*Pelicanus erythrorhynchos*). *In:* The birds of North America. No. 57 (A. Poole and F. Gills, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania USA and The American Ornithologists' Union, Washington, D.C. 24 pp.

Fielder, P. C. and R. G. Starkey. 1986. Bald eagle perch sites in eastern Washington. Northwest Science. 60:186-190.

Grier, J. W. 1982. Ban on DDT and subsequent recovery of reproduction in bald eagles. Science 218:1232-1235.

Harmata, A. R., and B. Oakleaf. 1992. Bald Eagles of the Greater Yellowstone Ecosystem: An ecological study with emphasis on the Snake River, Wyoming. Wyoming Game & Fish Dept., Lander. 368 pp.

Hunt, W. G., E. W. Bianchi, D. E. Driscoll and R. E. Jackman. 1992. Ecology of nesting bald eagles in Arizona. Report by BioSystems Analysis, Inc. to USDI, Bur. Reclamation, Lower Colorado Region, Boulder City, NV. Contract No. 6-CS-30-04470.

Jensen, K. C. 1988. Nest site selection by bald eagles in Montana. MS thesis. Montana St. Univ., Bozeman. 56 pp.

Koonz, W. H. 1981. White pelicans at nuisance grounds. Blue Jay 39(2):102-103.

Knopf, F. L., and J. L. Kennedy. 1981. Differential predation by 2 species of piscivorous birds. Wilson Bulletin 93:554-556.

Lies, M. F., and W. H. Behle. 1966. Status of the white pelican in the United States and Canada through 1964. Condor 68:279-292.

Lingle, G. R., and N. F. Sloan. 1980. Food habits of white pelicans during 1976 and 1977 at Chase Lake NWR, North Dakota. Wilson Bulletin 92:123-125.

Mattson, J. P. 1974. Interaction of a breeding pair of bald eagles with subadults at Sucker Lake, Michigan. MA Thesis, St. Cloud State University, St. Cloud, Minnesota. 51 pp.

McMahon, B. F., and R. M. Evans. 1992. Nocturnal foraging behavior in the American white pelican. Condor 94:101-109.

Mersmann, T. J., A. Buehler, J. D. Fraser and J. K. D. Seegar. 1992. Assessing bias in studies of bald eagle food habits. Journal of Wildlife Management. 56:73-78.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Midland Nat. 37:233-249.

O'Malley, J. B. E. and R. N. Evans. 1984. Activity of American white pelicans (*Pelicanus erythrorhynchos*) at a traditional foraging area in Manitoba. Canadian Field-Naturalist 98:383-390.

Roney, K. 1982. 1980 census of Saskatchewan pelican and double-crested comorant colonies. Blue Jay 40:158-160.

Roney, K. 1984. 1982 census of Saskatchewan pelican and double-crested comorant colonies. Blue Jay 42:77-82.

Rüppell, G. 1977. Bird flight. Van Nostrand Reinhold Co., New York. 91 pp.

Sidle J. G., W. H. Koonz, and K. Roney. 1985. Status of the American white pelican: An update American Birds. 39:859-864.

Sloan, N. F. 1982. Status of breeding colonies of white pelicans in the U.S. through 1979 American Birds. 36:250-254.

Snow. C. 1973. Habitat management series for unique or endangered species. Bald eagle. U.S. Department of Interior, Bureau of Land Management. Report. No. 5, Denver Service Center, Federal. Center., Denver, Colorado. 58 pp.

Stalmaster, M.V. 1987. The bald eagle. Universe Books, New York. 227 pp.

Taylor, R.L. and M. Lott. 1978. Transmission of Salmonid Whirling Disease by Birds Infected with *Myxosoma cerebralis*. Journal of Protozoology. 25(1)105-106.

Todd, C.S., L.S. Young, R.B. Owen, Jr. and F.J. Gramlich. 1982. Food habits of bald eagles in Maine. Journal of Wildlife Management. 46(4):636-645.

Trottier G. C., R. J. Breneman and N. A. Young. 1980. Status and foraging distribution of white pelicans , Prince Albert National Park, Saskatchewan. Canadian Field-Naturalist 94:383-390.

Udvardy, M. D. F. 1977. The Audubon Society field guide to North American birds, western region. Alfred A. Knopf, Inc., New York.

Vermeer, K. 1970. Distribution and size of colonies of white pelicans, (*Pelicanus erythrorhynchos*), in Canada. Canadian Journal of Zoology 48(5):1029-1032.

Watson, J. W., M. G. Garrett, and R. G. Anthony. 1991. Foraging ecology of bald eagles in the Columbia River Estuary. Journal of Wildlife Management 55(3):429-499.

Wright, M. and R. E. F. Escano. 1986. Montana bald eagle nesting habitat macro-habitat description. U.S. Department of Agriculture, Forest Service., Missoula, Montana. 24 pp. plus appendices.

Yates, R. E. 1989. Bald eagle nesting ecology and habitat use: Lake McDonald, Glacier National Park, Montana. M.S. Thesis. University of Montana, Missoula. 102 pp.

CURRENT RESEARCH ON THE APPROVAL OF CHLORAMINE-T FOR USE IN PUBLIC AQUACULTURE

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Abstract

Chloramine-T is widely regarded as one of the most effective therapeutants used to control mortality in fish caused by bacteria associated with bacterial gill disease (BGD). However, the Food and Drug Administration (FDA) has not approved chloramine-T for use in any food animal, including fish. Therefore, before chloramine-T can be legally used in aquaculture without Investigational New Animal Drug (INAD) authorization, all technical sections necessary for approval of a New Animal Drug Application must be submitted and approved. Such technical sections include pivotal data on efficacy, target animal safety (TAS), human food safety, and environmental fate.

The USFWS Bozeman Fish Technology Center (BFTC) National INAD Office (NIO) is working cooperatively with FWS hatcheries, the USGS Upper Midwest Environmental Sciences Center, and Akzo-Nobel Chemicals, Inc. to generate the necessary data to gain FDA approval of chloramine-T for use in aquaculture. The BFTC has been responsible for conducting pivotal, near-pivotal, and ancillary chloramine-T field efficacy trials on salmonids, as well as pivotal TAS trials on various life stages of rainbow trout (Oncorhynchus mykiss). The efficacy of 12 - 20 mg/L chloramine-T has been tested on a variety of salmonids. The objective of each efficacy study has been to determine if chloramine-T treatments can control mortality in fish diagnosed with BGD. Results of efficacy studies have varied with respect to degree of "success", but nearly all treatments have been found to be efficacious. Results from TAS studies have also been promising. Regulated studies have been completed at two water temperatures for rainbow trout fry, fingerling and juvenile life stages. Groups of fish have been exposed to chloramine-T concentrations ranging from 0 to 100 mg/L for 3 hr in a standing bath on 3 alternate days at both 8 or 14° C. Study results have shown that there is a positive correlation between toxicity of chloramine-T and both fish size and water temperature. Additional TAS studies are planned and this work should be completed before the end of FY2000. Final approval of chloramine-T will depend on a review and approval of the complete data package by FDA (which would include submissions for human food safety and environmental fate).

Background

Bacterial gill disease (BGD) is one of the most common diseases of hatchery reared salmonids (Bullock 1991) and is the cause of more fish losses than any other bacterial disease (Bills et al. 1988). In Ontario, Canada, BGD accounts for nearly 21% of all diagnostic submissions from fish farms to the Fish Pathology Laboratory of the Ontario Veterinary College (Ferguson et al. 1991). Death is generally not a direct result of the infection, but is a consequence of the pathogen load. In the case of BGD, death is most likely the result of asphyxiation from lack of adequate oxygen exchange at severely congested gills. Stressors associated with intense fish culture may predispose fish to infection. Proliferation of gill epithelial tissue and subsequent loss of gill surface by clubbing and fusing of lamellae are often associated with BGD infections (Bullock 1990). The disease is characterized by an acute onset, flared opercula, increased branchial rate and decreased fright response. In addition, fish spaced equidistantly from each another, reject feed, and high mortality is observed (Lumsden et al. 1994; Lasee 1995). If BGD, which is horizontally transmitted, is not diagnosed and treated during the early stages of infection, thousands of fish may die within a 24-h period (Bullock et al. 1990).

Historically, a number of chemicals including benzalkonium chloride (available as Hyamine 1622 and 3500), diquat, and chloramine-T have been used to control mortality caused by BGD (Bullock et al. 1990). However, none of these available chemicals are approved by the U.S. Food and Drug Administration (FDA) to control mortality in freshwater fish caused by BGD or any other infectious pathogen. Because chloramine-T is generally regarded as the most effective therapeutant when salmonids have BGD (From 1980; Bullock et al. 1990), it has become the prime candidate for FDA approval as a bath treatment. Chloramine-T has been characterized as a non-selective sanitizing agent and has been shown to “clean up” gills infested with bacteria and coated with excess mucus. In order for a chemical such as chloramine-T to be approved for use in aquaculture, it must be proven to be efficacious in field trials, and pose no toxicological effects to exposed fish at the proposed therapeutic levels. Both efficacy and target animal safety studies, conducted to meet the FDA Center for Veterinary Medicine (CVM) minimum requirement for clinical and non-clinical field trials, are necessary components of a New Animal Drug Application submission. Efforts have been underway since 1997 to generate pivotal clinical field efficacy trials, and more recently, target animal safety (TAS) studies have been conducted to evaluate the toxicity of chloramine-T. Efficacy data generated to date, including data from both pivotal and non-pivotal trials, indicate chloramine-T treatment concentrations up to 20 mg/L to be efficacious while showing no indication of toxicological effects. Additionally, a series of target animal safety studies conducted at the NIO, which evaluated mortality among various life stages of rainbow trout exposed to ≤ 100 mg/L chloramine-T for 3 hours at 8 and 14° C, also demonstrated no toxicity at 20 mg/L chloramine-T.

This presentation will summarize results of pivotal field efficacy and TAS studies conducted to date by the NIO and the U.S. Fish and Wildlife Service field stations. It will also describe other efficacy and TAS studies that still need to be completed, and an approximate time line anticipated for their completion and submission to CVM.

A total of 6 pivotal field efficacy trials have been completed. Species tested include Chum salmon (*Oncorhynchus keta*), rainbow trout (*O. mykiss*) and Apache trout *(O. apache*). Chloramine-T has been tested at concentrations ranging from 12 to 20 mg/L for 1 h using both flow through and standing bath treatment methods. Treatments were administered 3 times on either alternate and consecutive days. Mortality was the primary response variable, and in nearly all cases mortality among treated groups was significantly less than among untreated groups. Table 1 summarizes efficacy data generated to date. Study reports for all studies have been completed. A report summarizing three of the reports was prepared by staff at the Upper Midwest Environmental Sciences Center and all four reports were packaged as a formal submission to CVM in August 1998 for review.

Table 1. Summary of pivotal studies conducted from 1997 through 1999. Table includes species test, treatment regime used, summary proportional mortality, whether differences were significant, how many of the quality criteria were met[1], and location of the study[2].

Fish Species	chl-T conc.	treatment frequenc	treatment	mortality		Sign. diff.	Q. C.[1]	Study Location[2]
				T	U			
RBT	15	alternate	flow	56.8%	65%	Yes	11 of 12	Neosho
CHS	12	alternate	standing	8.6%	97.6%	Yes	12 of 12	Quilcene
APT	12	alternate	standing	30%	98.1%	Yes	12 of 12	A-W C
RBT	13.2	alternate	standing	6%	25.6%	Yes	11of 12	Hotchkiss
APT	20	alternate	standing	8.7%	98%	Yes	12 of 12	A-W C
RBT	20	consecutive	standing	5%	7.2%	No**	11of 12	Jones Hatchery

[1] Quality Criteria include the following: (1) disease identification; (2) data collected through the epizootic; (3) use of controls; (4) absence of known secondary disease agent(s); (5) quality control of data; (6) no concomitant therapy; (7) blinding techniques used; (8) randomization procedures used; (9) analytical confirmation of dosage; (10) replicates; (11) treatment consistent with proposed therapy; and (12) fish from a single test lot.

[2] Location of studies: Neosho National Fish Hatchery, Neosho, MO; Quilcene NFH, Quilcene, WA; Alchesay - Williams Creek NFH Complex, Whiteriver, AZ; Hotchkiss NFH, Hotchkiss, CO; Jones Hatchery, Hagerman, ID.

** There was no significant difference in mortality between treated and untreated groups. However, there was significant differences between the 2 groups of fish in the amount of bacteria present on gills.

A report will be prepared summarizing the remaining three study reports and will soon be submitted to CVM along with the following draft label claim:

Draft Label Instructions
For use on all salmonids susceptible to bacterial gill disease.

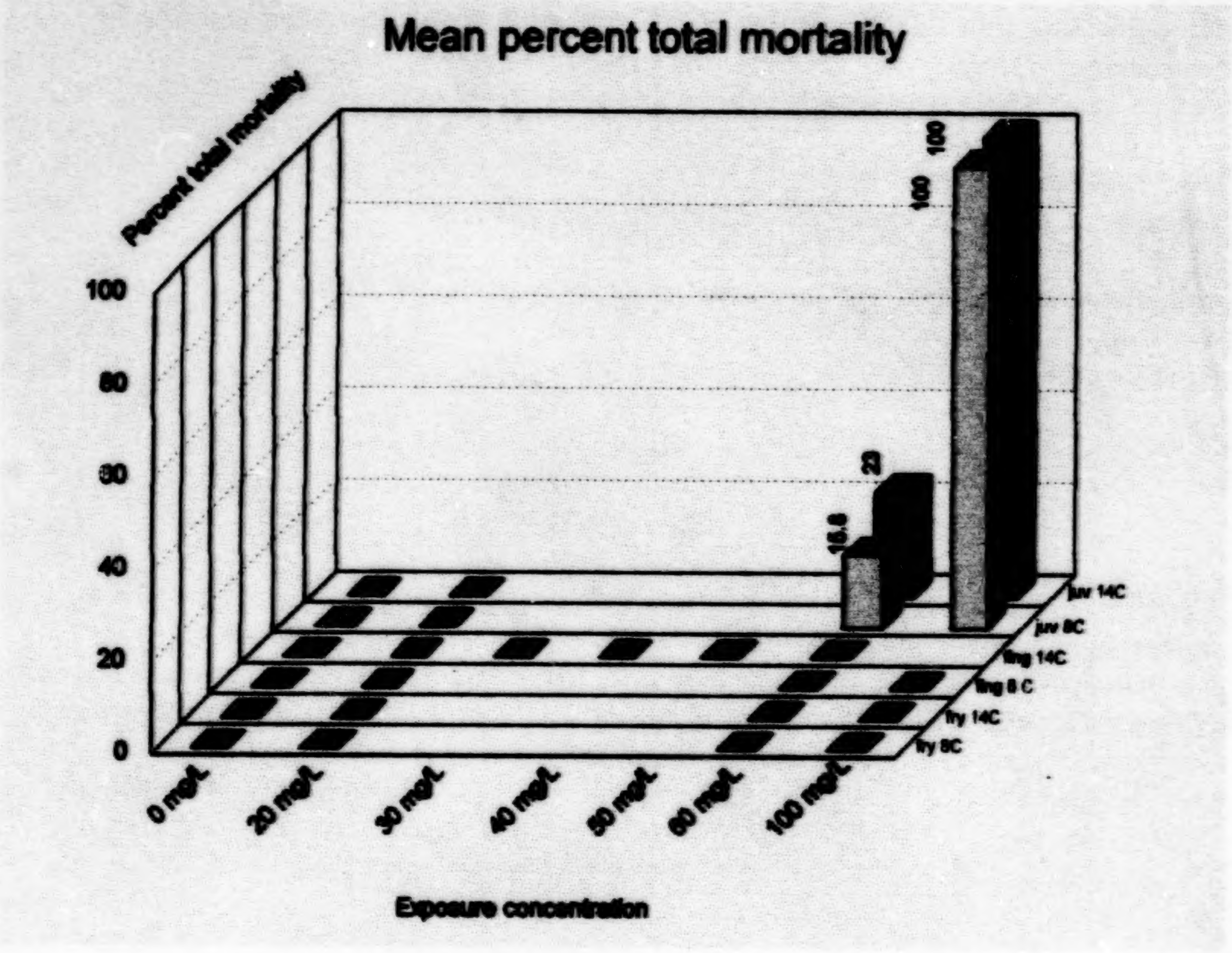
Indications: For the control of mortalities caused by bacterial gill disease.

Directions for Use:

> **Disease Control:** Treat fish at between 12 and 20 mg/L chloramine-T, in a 1 h standing bath or flow through immersion treatment, no more than once per day, on alternate days for a total of no more than three treatments per epizootic.

Current plans call for one additional pivotal efficacy study to be conducted at the Alchesay - Williams Creek NFH. The study will evaluate the efficacy of 10 mg/L chloramine-T administered for 1 h on three alternate days to control mortality in rainbow trout caused by BGD. If the study is successful, the directions of the proposed label will be modified to allow use of chloramine-T at concentrations between 10 and 20 mg/L.

The NIO has also initiated a series of TAS studies on various life stages of rainbow trout. Requirements for TAS studies are more stringent that for efficacy studies, as all TAS studies must be conducted according to Good Laboratory Practice standards. To date, studies have been conducted on fry, fingerling and juvenile rainbow trout at both 8 and 14° C. Fish were exposed to chloramine-T concentrations ranging from 0 - 100 mg/L for 3 h in a standing bath on three alternate days. Results are summarized in Figure 1. In summary, there appears to be a positive correlation between chloramine-T toxicity and both age of fish and water temperature. Older fish were more sensitive to chloramine-T toxicity, and the chemical appears to be more toxic at higher water temperatures. A number of additional studies remain to be conducted. Included is a study to determine the toxic threshold of chloramine-T to fingerling and juvenile rainbow trout when tested at 14° C. These life stages will also be used in a study to determine based on histological evaluation whether damage occurs to external surfaces (e.g., gills, skin, eyes) and/or internal tissue (kidney) when fish are exposed to sublethal concentrations of chloramine-T. If damage does occur to these tissues, then it will be important to determine whether the damage is reversible. Study plans also include the testing of adult rainbow trout at various concentrations of chloramine-T at two temperatures. It is anticipated that all above mentioned studies will be completed during the next 6 to 8 months. Analysis of data and evaluation of tissue by a certified histopathologist will likely require an additional 4 to 6 months. Reports will be prepared summarizing results from all studies, and a complete data package of this work will be submitted to CVM before the end of CY2000.


Mean percent total mortality
Percent total mortality
100
80
60
40
20
0
100
100
16.6
20
juv 14C
juv 8C
fing 14C
fing 8 C
fry 14C
fry 8C
0 mg/L
20 mg/L
30 mg/L
40 mg/L
50 mg/L
60 mg/L
100 mg/L
Exposure concentration

WASHINGTON STATE WARMWATER
GAMEFISH ENHANCEMENT PROGRAM

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Abstract

The Washington Department of Fish and Wildlife's "warmwater" game fish enhancement program began in 1997 at the request of fishing organizations interested in bass, walleye, and other warmwater fish species that are found in Washington.

The enabling legislation authorized WDFW to fund the program through a $5 fishing license surcharge. Today the enhancement funds come from a share of the freshwater fishing license dollars. Prior to 1999, adult anglers paid $17 for a fishing license and an extra $5 to fish for bass, channel catfish, crappie, tiger musky, and walleye. Starting in 1999, adult anglers pay $20 for a license that covers all freshwater fishing.

Goals and Objectives of the Warmwater Enhancement Program

The Warmwater Gamefish Enhancement Program's goals is to increase opportunities to fish for and catch warmwater game fish. To do so, the program emphasizes field activities and the use of cooperative groups and volunteers whenever possible to minimize costs and gain the greatest return for the investment. The program also ensures no negative impacts to conservation of native anadromous species or other native species of fish and wildlife

Initial objectives and tasks included:

* Develop new lakes and ponds for warmwater fishing
* Provide more public access to existing warmwater fisheries
* Purchase and produce warmwater fish for stocking
* Develop and maintain an urban component to the program
* Evaluate new species and strains for introduction to state waters
* Use lake rehabilitation to improve warmwater fishing
* Use a variety of habitat-improvement projects to enhance warmwater fish populations
* Prevent the importation of deleterious exotic fish species

Accomplishments to date:

In the first two years of the Warmwater Gamefish Enhancement Program, WDFW has:

- **Stocked more that two million bass, walleye, tiger musky, channel catfish, crappie and bluegill sunfish into more than four dozen Washington lakes, ponds and reservoirs.**
- **Conducted biological investigations on more than 40 Washington lakes to determine the best methods to enhance fishing in these waters.**
- **Rehabilitated three lakes to remove undesirable fish populations, and restocked these lakes with more desirable warmwater game fish species.**
- **Placed artificial habitat structure into five waters to enhance them for warmwater fish.**
- **Completed planning and improvements to provide more public access on over two dozen state waters, including fishing piers, a new public access on Sprague Lake, and other similar projects.**
- **Initiated research to determine how to enhance warmwater fishing without adversely impacting native fish and wildlife populations.**
- **Established two new juvenile fishing waters for warmwater game fish.**
- **Increased efforts to protect Washington's freshwater ecosystem from deleterious exotic species such as zebra mussel.**
- **Funded a major research effort to determine the impact of warmwater fish on various species of native fish and wildlife.**
- **Provided funding to complete construction of the new Rod Meseberg Warmwater Facility.**

Future Program Development:

Expansion of the Rod Meseberg Warmwater Facility

Acquire and develop new nature rearing sites around the state for production.

Utilize existing local stocks for captive brood stock.

EVALUATION OF HATCHERY OUTPLANT RELEASE STRATEGIES FOR SPRING CHINOOK SMOLTS IN THE TUCANNON RIVER

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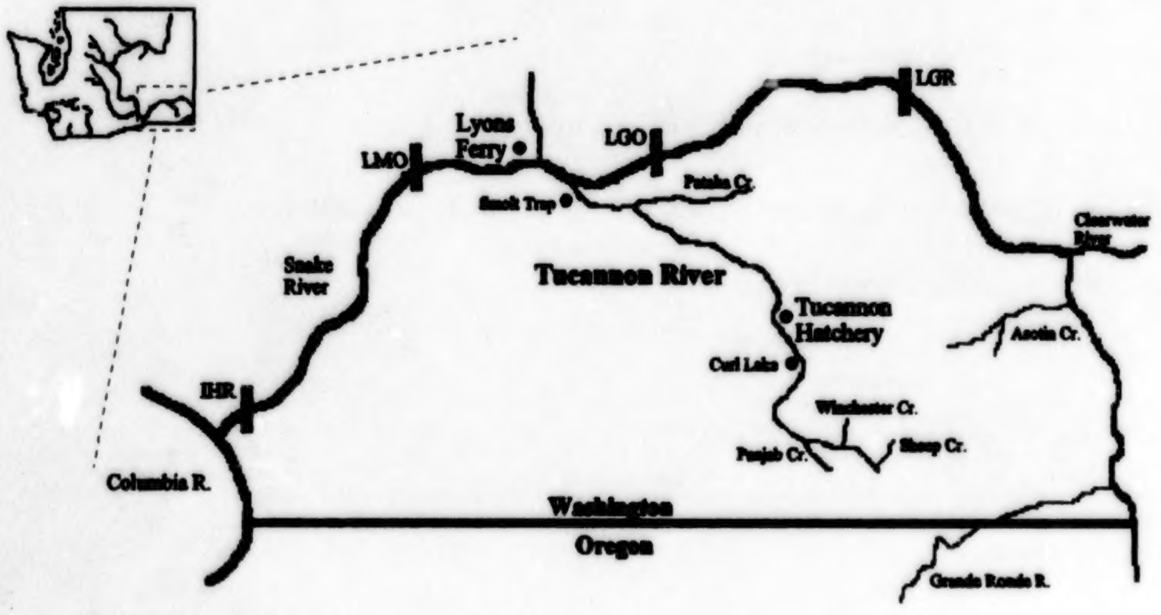
Background

With completion of the four Lower Snake River Dams, hatchery mitigation facilities (Lyons Ferry Hatchery-LFH, and Tucannon Hatchery-TFH) were constructed/modified to compensate for losses of returning adult salmon to the Snake River. One objective of these hatcheries was to compensate for the loss of 1,152 adult Tucannon River spring chinook salmon. In 1985, the WDFW initiated a hatchery supplementation program for spring chinook by trapping returning wild adults at TFH (Rk 58). Trapped fish are hauled to LFH, spawned, the progeny reared for 10 months, then transported back to TFH for acclimation and release (132,000 smolts). Also in 1985, a hatchery evaluation program was started to: 1) monitor the wild spring chinook production in the river, 2) determine the success of the hatchery program in meeting the mitigation goal, and 3) document effects the program may have on the natural population.

Figure 1 - Tucannon River Basin



After nearly 15 years of monitoring, the evaluation program has determined that the wild population is below replacement, and the hatchery population returns at 2-3 times replacement. Therefore; the hatchery population is playing a critical role in maintaining the spring chinook population in the river, and presently is the only means of preserving the stock for the future.

Study Justification

After 10 years of monitoring redd numbers, a disturbing trend in the spawning distribution was observed (Figure 2). The number of redds above the TFH trap was declining, while redds below the trap increased. Summer rearing temperatures (Figure 3) and degraded habitat below TFH is not optimal for survival. Therefore; progeny survival from redds below the trap may be less. Temperature and habitat conditions above the hatchery are better. Reasons for the shift in spawning distribution were: 1) broodstock collections "mined" wild fish from the river which typically spawned 10-20 km above TFH, 2) juveniles were released at TFH, and returning hatchery adults appeared to be homing in on the hatchery, 3) high pre-spawning loss of hatchery origin fish passed above the TFH trap reduced the initial potential of more redds above the trap, and 4) a migration barrier (weir) to some fish caused by the TFH trap.

Figure 2 - Redd Counts

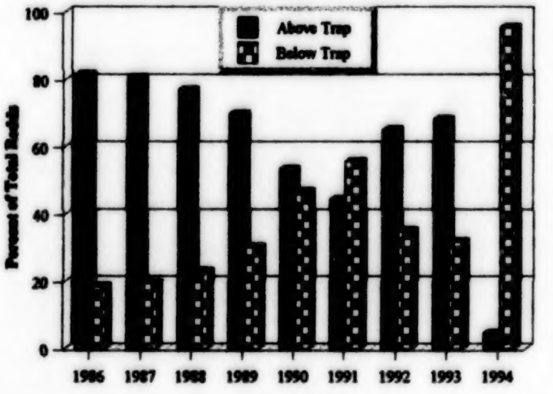
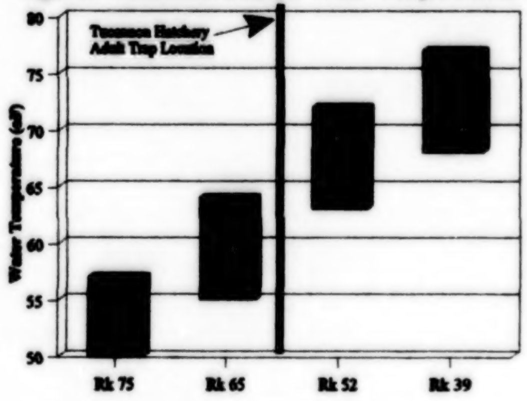


Figure 3 - Maximum Summer Water Temperatures



For those reasons, increasing redds below TFH and potentially reduced survival of juveniles forced the hatchery program to examine its release strategy. It was reasoned that releases of smolts upstream of TFH would have to occur to reverse the shift in spawning distribution. Unfortunately, no permanent facilities existed upstream of the hatchery. Direct stream releases or releases from small portable acclimation ponds were then proposed, with the intent that adults would return to their approximate point of release. However, both strategies were questioned by management. It was feared that transporting smolts just prior to release would lead to unacceptably high mortality. However, with no other choices except to continue current releases, managers decided to try both proposed release strategies with some fish, while maintaining a large traditional release (90,000) from TFH. The evaluation program was given the task to monitor all aspects of releases, downstream migration, and adult returns.

For the three study years presented (1995-1997 releases), there were three main release groups: 1) TFH - acclimated release , 2) Portable Ponds - acclimated release, and 3) direct stream release. All releases from portable ponds or directly to the river were released between Curl Lake (Rk 66) and Sheep Creek (Rk 84) (Figure 1). Fish released by the three methods were given unique Coded-Wire Tag codes for smolt-to-adult survival information.

For planning the next years smolt release, evaluation methods were needed that could determine the success of each release strategy, without waiting for adult returns. Three techniques were used: 1) Blood Plasma Cortisol levels (stress indicator), 2) smolt trapping, and, 3) Passive Integrated Transponder (PIT) tagging. To determine origin of fish at the smolt trap, fish from the various release types were also tagged with a Visual Implant (VI) elastomer tag. Catches at the smolt trap could then be separated by release type.

Results: During all three release years, 20-60 fish per release group were sacrificed to determine stress levels based on blood plasma cortisol analysis. As expected, stress levels from fish transported and direct stream released were markedly higher (Figure 4) than the groups released from TFH or portable acclimation ponds. However, it was unknown wether this stress level would impact survival, or if the fish would recover and perform as well as the acclimated releases.

Following release, fish were captured in the smolt trap located near the Tucannon River mouth (Figure 1). Based on VI tags, survival and descaling rates were estimated for each release type (Figures 5 and 6). For two of the three years, direct stream released fish appeared to have higher survival rates than either acclimated group, though descaling rates were always higher. Descaling rates, like the cortisol results, were expected to be higher than the other groups as they were transported later, and were possibly more smolted. Only for the 1997 migration did estimated survival of the outplant groups appear to be less than the group released from TFH.

PIT tag detection percentages mimicked smolt trap survival estimates, and do not reflect the cortisol and descaling results. Direct stream released fish (released at Curl Lake, Rk 66) were detected at a higher rate than all acclimated group (TFH, Curl Lake, and Winchester) for 1995 and 1996 releases (Figure 7). However, not all direct stream released fish performed as well. Because PIT tagged fish could be isolated to release location and type (VI tags could not), we determined that releases in the upper most reaches of the river did not survive as well as groups released lower (1995 Winchester site release). Consequently, because of the PIT tag results, smolts releases in the upper reaches were discontinued after 1995.

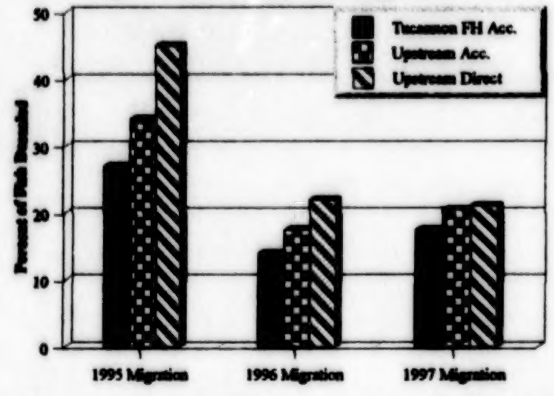


Figure 6 - Smolt Trap Descaling Rates

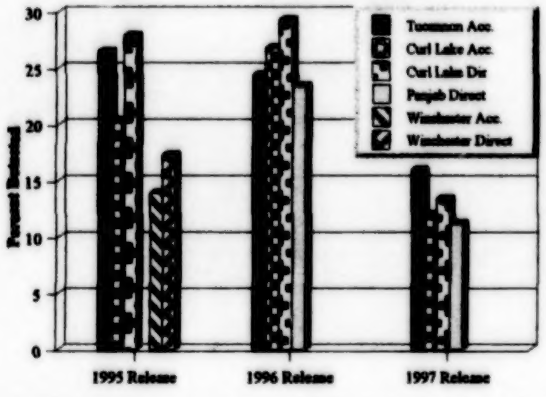


Figure 7 - PIT Tag Detection Rates

Discussion: Based the three years of data compiled, we were able to show overall that transporting smolts to small, portable acclimation ponds, or conducting direct stream releases was possible, and did not appear to result in a greater mortality than what was experienced from the standard release at TFH. Further, the evaluation on juveniles was valuable in quickly identifying optimal release points, allowing managers to make appropriate decisions for upcoming releases. What remained to be determined was wether adult survival would follow that which was documented for juveniles. Adult returns are nearly complete for the 1995-1997 release years (Figure 8). Based on the adult return data, no survival difference is apparent, and no one release particular strategy appears to be best.

Based on initial study results, early adult returns, and other management changes within the basin, by the 1998 release managers had shifted to releasing 80% of the smolts upstream of the hatchery. By 1999, all releases occurred upstream of the hatchery (100% of the fish in Curl Lake Acclimation Pond). Unfortunately, because adult returns have been low since 1994, nearly

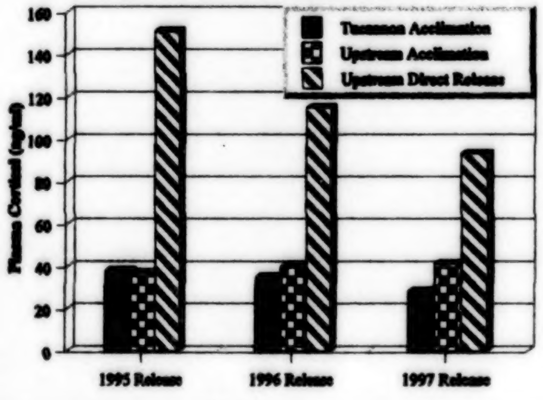


Figure 4 - Stress Levels at Release

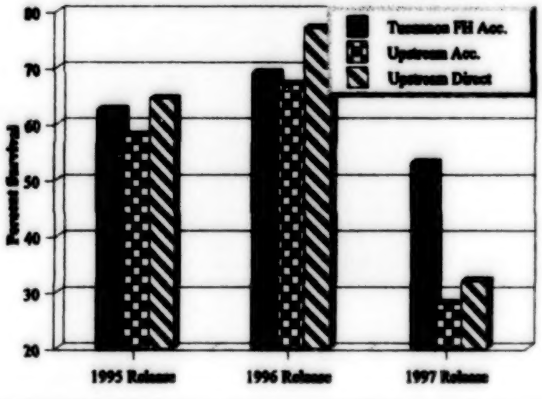


Figure 5 - Smolt Trap Survival Estimates

all returning fish (wild and hatchery) have been trapped at TFH for broodstock in an effort to preserve the stock, which has exacerbated the shift in spawning distribution (Figure 9). Moreover, since most of the fish have been collected, it has severely limited our ability to document the relative homing ability of fish released above the hatchery, to see if our efforts were worthwhile.

Figure 8 - Smolt-to-Adult Survival

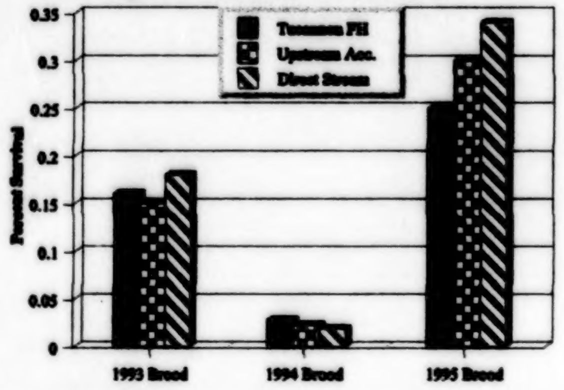
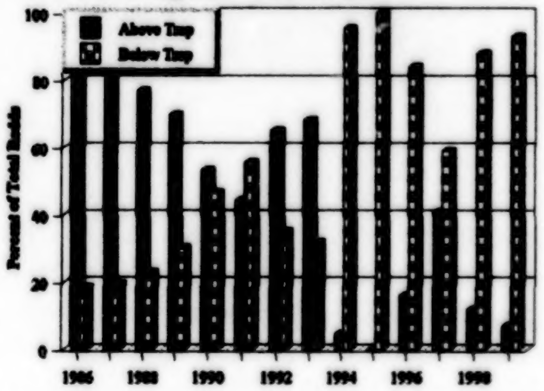


Figure 9 - Redd Counts



INTROGRESSIVE HYBRIDIZATION BETWEEN RAINBOW AND CUTTHROAT TROUT IN HENRY'S LAKE, IDAHO

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Abstract

For the past 30 years the IDFG has operated a spawning station on Henry's Lake to produce a trophy fishery of cutthroat Oncorhynchus clarki X rainbow Oncorhynchus mykiss hybrid trout. Eggs have also been collected for the production of pure Yellowstone cutthroat trout Oncorhynchus clarki bouvieri since the mid-1920's. Yellowstone cutthroat are produced to offset declines in natural production due to spawning habitat losses in Henry's Lake following construction of a dam at the outlet in 1924.

Each spring, spawning cutthroat return up Hatchery Creek to the spawning station on Henry's Lake. Returning cutthroat females are divided into two groups. Eggs from one group are fertilized with milt from selected returning cutthroat males. Eggs from the second group are fertilized with rainbow trout milt from Hayspur Hatchery, ID. The intentional hybridization program continues because of the large size and good condition the hybrids attain. The success of the Henry's Lake hybrid program as well as the future of the cutthroat fishery rely on the ability of managers to differentiate returning hybrids from returning cutthroat.

Male and female cutthroat trout and hybrids were sampled for two seasons as they returned to the hatchery. Sampled fish were identified as a cutthroat or a hybrid using several phenotypic characters such as pigmentation, size, and spotting pattern employed at the hatchery. Fish were subsequently examined using diagnostic allozyme loci, microsatellite fragment analysis, RFLPs of nuclear gene loci, and mitochondrial RFLPs. Additionally, cutthroat trout were collected and likewise examined from several tributaries of Henry's Lake to assess possible introgressive hybridization among those populations. Results indicate the phenotypic characters used to identify and select pure cutthroat females were not entirely accurate particularly during the later portions of the run.

THERMALLY INDUCED OTOLITH MARKING OF KOKANEE SALMON

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Abstract

The effect of thermal events on the otolith is nearly immediate, and a scheduled pattern of temperature changes will faithfully record a pattern on the otolith as a series of optically dense bands and intervening spaces (Volk, 1994). In order to evaluate the success of a kokanee (Oncorhynchus nerka) stocking program in Lake Pend Oreille, and otolith thermal mass-marking (T-marking) program was initiated at Cabinet Gorge Hatchery, Clark Fork, Idaho. Approximately 4.0 million kokanee were T-marked in 1996, 2.7 million kokanee T-marked in 1997, and 8.0 million T-marked in 1998. Trawl surveys on Lake Pend Oreille collected samples to be examined to determine the proportion of otolith marked hatchery fry versus non-marked wild fry.

NATIONAL INAD PROGRAM – PARTICIPATION BY NON-USFWS ENTITIES ON USFWS INADS

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Abstract

In April 1998, the U.S. Fish and Wildlife Service (Service) took a major step in expanding both the scope and magnitude of its Investigational New Animal Drug (INAD) program by opening participation on Service INADs to state, tribal, university, and private aquaculture facilities. Although initial participation in the program was limited to folks in the States of Alaska, California, Idaho, Montana, Oregon, and Washington, in January 1999 the program was expanded to include participation by facilities from throughout the entire United States The new program has been termed the National INAD Program (NIP), although it is more commonly referred to as "Piggy-backing" on Service INADs.

The National INAD Program is an official program of the Service, and was established to facilitate consolidation of the INAD process, eliminate duplication of effort, reduce workloads and costs, ensure compliance with FDA guidelines, and ensure the submission of data that are necessary for future drug approval and drug labeling. The National INAD Program is a cost reimbursable program established under the direction and supervision of the Service's INAD Sponsor to ensure needed drugs, chemicals, and therapeutants are available to all aquaculture programs in the United States. The INAD Sponsor (through Cooperator funding) provides full administrative support for the office and staff of the National INAD Program.

To date, the NIP has been a resounding success. It has not only provided a mechanism for aquaculturists throughout the United States to continue to have access to needed drugs/therapeutants, but has also resulted in a the formation of a large, consolidated database of drug use efficacy data that can be used to support new animal drug approvals. Current participation includes 151 facilities located in 21 states scattered throughout the country. The NIP has experienced no regulatory or compliance problems associated with INAD drug use by NIP participants, and virtually all feed-back from participants has been positive. For additional information concerning the National INAD Program, please contact Dr. David Erdahl or Ms. Bonnie Elliott at (406) 587-9265 ext. 125 (Dave) or 136 (Bonnie).

REARING SALMON AND STEELHEAD IN HIGH-DENSITY MICHIGAN RACEWAYS: UMATILLA HATCHERY PROGRESS REPORT

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Abstract

Salmon and steelhead released in the Umatilla River have been reared in Michigan raceways at Umatilla Hatchery since 1992. These raceways produce more fish with less water by utilizing oxygen supplementation in a triple pass design. To test the effectiveness of these raceways, groups have been monitored to evaluate smolt quality, migration performance, and adult survival. When possible, these release groups were compared to groups reared in standard raceways. Subyearling fall chinook salmon have been reared in Michigan and standard raceways and our evaluation suggests the quality of fish produced in each system is similar. By rearing subyearlings in a Michigan series of raceways, we have produced approximately 950 fish/gpm compared to 320 fish/gpm in standard raceways. Recovery of marked juveniles at mainstem Columbia River dams suggests the migration travel time and survival of subyearlings reared in Michigan raceways and standard raceways was similar. Analysis of CWT data has been hampered by low recovery rates caused by a combination of poor migration survival out of the Umatilla River and poor ocean conditions. However, adult survival has been similar for both groups and suggests the MI raceways may be an effective fish culture technique for rearing subyearling chinook salmon. Because of a limited water supply, steelhead have been reared only in MI raceways at Umatilla Hatchery. However, production in a Michigan series of raceways has averaged 158 fish/gpm compared to an estimated production of 80 fish/gpm in standard raceways. Moreover, smolt-to adult survival of steelhead has been greater than 1% in some years and suggests these fish can be successfully produced in MI raceways. We are currently conducting studies to evaluate the maximum production of subyearling fall chinook salmon in MI raceways and plan to rear steelhead concurrently in Michigan and standard raceways.

A TRIAL OF THREE STARTER FEEDS ON STEELHEAD FRY AT DWORSHAK NATIONAL FISH HATCHERY

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Dworshak National Fish Hatchery
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Abstract

Steelhead at Dworshak National Fish Hatchery are reared from green eggs to smolts in a 12 month program which employs several reuse systems in order to rear the fish to a target release size of 180 to 220 mm in length. It is necessary to utilize reuse systems for the later takes of fish in order to heat the water so that these later fish will make size. The emphasis year round at Dworshak NFH is to maximize growth rates. Swim up steelhead fry at Dworshak National Fish Hatchery have traditionally been fed Bio Oregon's Bio diet starter feeds. Recently, Bio Oregon and Moore Clark feed companies have developed new starter diets. Bio Oregon has developed a floating flake starter feed and Moore Clarke has developed a crumble type starter feed. Both companies claim that these new feeds are an improvement over past feeds and will result in faster growth rates and improved feed conversions. A faster growth rate in the Dworshak nursery would result in steelhead fry being ponded outside at a larger size. This would shorten the time the fish would need to be on reuse during the winter months to reach release size. This would be advantageous since reuse is expensive to run and is also stressful on the fish. If the new feeds demonstrate improved conversion rates, it could translate to lower feed costs for the hatchery.

Twelve nursery tanks from BY99 spawning, take 7, were used. The tanks were split into three test groups of four tanks each. Bio Oregon starter diet was fed to the first group as the control. The other two groups were fed Bio Oregon flake starter diet and Moore Clark Nutra Starter. The tanks were stocked with 17,500 fish each. Beginning at swim up, a tub with a lid was placed next to each study tank. Each tank was fed from its corresponding tub. The fish were fed to satiation hourly, eight times a day, which is the standard feeding procedure for the Dworshak nursery fish. The feed was weighed into the tubs and remaining feed was back weighed at the end of the month to determine the total amount fed to each tank and calculate feed conversion. Approximately 25 fish were netted from each tank on three occasions and the length and weights were recorded. These data will be used to calculate mean length and weight for each tank, construct a length frequency distribution, calculate monthly growth rate as change in length (delta L), calculate feed conversion as pounds of feed fed per pounds of fish gained, and cost per pound of fish gained.

FISH COUNTING & BIO-MASS ASSESSMENT EQUIPMENT

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www.W-M-T.com

Abstract

The need for more accurate assessment of salmonid stocks in Northwest USA rivers is now heightened because of the Federal Endangered Species Act. National Marine Fisheries has developed guidelines for hatcheries releasing fish in rivers with ESA listed stocks. These guidelines now require hatchery managers to improve the accuracy of numbers and size of fish released from hatcheries in an attempt to lower stray rates and residualization (NMF section 10 permit, sub section 901, 902). Water Management Technologies, Inc., USA distributor of Vaki Fish Counting Technology offers fish counting and bio-mass assessment equipment to count adult Salmon migrations upstream through fish ladders, traps and cages as well as equipment to count volitional smolt migrations out of hatcheries, fish screens and dams. All products employ infra red technology enabling the equipment to operate day or night and in extremely turbid waters (2.3 inches on secchi disk).

The Vaki River Watcher provides accurate counting and assessment of salmon swimming through fish ladders, traps and cages. A record of the fishes' dimensions is taken for each fish. A silhouette image enables the viewer to determine hatchery versus wild fish by absence or presence of adipose fin. The River Watcher software distinguishes between fish passing upstream and downstream. The software also allows the user to program different size groups of fish and stores this information in the software's database for year to year comparison. Over 70 River Watcher's are installed and operating worldwide. The first unit was installed in 1993.

The Vaki Quattro Bioscanner is a high speed fish counter capable of counting 60,000 smolt per hour with +98 % accuracy. A Quattro is installed in a Washington State Fish Hatchery and will count smolt from a volitional release pond. All Vaki products are stress free counters that are fish friendly. Over 1100 Bioscanners have been sold since 1987.

"CAN-DO" HATCHERY OUTREACH PROJECTS

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Abstract

This poster presentation highlights a few innovative and cost-effective outreach projects that many hatchery stations could implement. These projects include: a high-tech touch screen information kiosk (Hagerman NFH); computer generated slide show for visitor orientation, student career fairs or any outreach event; a simple 2-sided newsletter produced in-house; "Fish Facts" Discovery Boxes and a "Wheel of Fish Fortune" activities for younger students. These ideas involve the help of outside partners, volunteers, students and creative hatchery staff. Supplies can be recycled materials, old or unused equipment; photos, surplus computer components, standard software programs, even natural items found around your station. Imagination and creativity are the only limits to your outreach programs, and of course the flexibility of hatchery managers is helpful. Each outreach project displayed has a cost breakdown, staff time involved, supplies and tools needed, anticipated audience, and learning goals/objectives.

OUTREACH LIFE CYCLE

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Abstract

As salmon and other fisheries concerns and issues become more prevalent and as our audiences grow in size and diversity, the need to provide hands-on learning experiences becomes critical. The only way to accomplish meaningful protection is to instill a sense of appreciation and understanding into every resident and visitor to our region. Innovative outreach, education, and interpretation is the key. Leavenworth National Fish Hatchery staff has developed creative year-round approaches to teach and share about Pacific Northwest fishery and watershed resources. Follow our "Outreach Life Cycle" and let us help you adapt some outreach tools and techniques to use at your site.

▸	*Kids in the Creek*	*-Create opportunities for high school students to jump into some waders and get wet! Join in a partnership with school district educators and teach watershed quality through a series of learning stations.*
▸	*Cascade Discovery Program*	*-Invite local school students to your site to explore your hatchery and the employees that work there. Incorporate mentorship programs into your daily routine.*
▸	*Wenatchee River Salmon Festival*	*--Share in the results of a successful curriculum that integrates quality natural and cultural resource education as it relates fisheries. Call us for a copy of this curriculum and adapt activities to your site.*
▸	*Hatchery Tours*	*--Share about hatchery operations and how they relate to the bigger picture of Pacific Northwest fishery resources by incorporating fun, hands-on environmental education activities.*

Open Houses	*--Turn your* ***spawning days*** *into* ***learning days*** *for your community and local schools. Invite them to help out.*
National Fishing Week	*--Using programs like "Pathways to Fishing," custom make a fishing event that teaches ethics in angling, fish biology, and habitat lessons.*
Cultural Exchange	*--Get to know to your local tribes and help them share the significance of salmon in their cultures to your visitors.*

EPIDEMIOLOGICAL STUDIES ON IHN VIRUS IN SACRAMENTO R. CHINOOK

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Abstract

Infectious Hematopoietic Necrosis Virus (IHNV) infection has affected Coleman National Fish Hatchery (CNFH) juvenile chinook production since the 1940's. Annual fish losses in the tens of thousands is not unusual, however, overall production loss ranges from only 2 – 4 % due to the large size of the CNFH program (12 – 28 million chinook released). In spite of the epizootics at CNFH, the virulence of the Upper Sacramento R. strain of IHNV has been shown to be relatively low. Disease progression observed in the hatchery has not been replicated in experimental work. Risk assessment on the source(s) of infection and impact on natural fish from infected CNFH fish requires viral strain-specific data. These studies address the factors necessary for infection and progression to a disease state, incidence of infection in the natural population, distribution of infected hatchery fish following release, and the interactions of natural fish with released hatchery juveniles.

Sentinel fish studies in CNFH's water supplies have failed to detect IHNV in spite of concurrent epizootics within the production raceways. No infected natural chinook juveniles have been detected in 3 years of sampling in the Upper Sacramento River. Infected (but largely asymptomatic) CNFH out-migrants have been collected as far as 183 rm for several weeks post-release. Clinically sick fish rapidly shed up to 10^3 Plaque Forming Units (PFU) / mL into the water and mucus from these fish can contain 10^5 – 10^7 PFU / mL. One minute water-borne challenges with as little as 100 PFU/mL results in infection; however, mortality is < 1%. Oral contact challenges also produce low rates of infection and little mortality. The incidence of infection (14%) and cumulative mortality (12.5%) from brief, low-level viral challenges was higher when fish were stressed post-exposure however, all groups remained asymptomatic throughout an 8 week study period.

The studies to date indicate that infection with Sacramento R. IHNV does not often lead to clinical disease in juvenile chinook and suggests that the ecological risk of infected hatchery fish may not be highly significant. Future study areas include the role of small birds in horizontal transmission within the hatchery, use of immunosuppressed fish for water supply sentinels, and a natural rearing experimental unit to examine sick hatchery fish interaction with natural chinook.Epidemiological Studies on IHN Virus in Sacramento R. Chinook.

EFFECT OF POVIDONE IODINE ON VIABILITY OF TYE TRIACTIHOMYXON STAGE OF *MYOXOBOLUS CEREBRALIS*

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Abstract

When fish eggs are collected from wild broodstocks and other sources outside the hatchery, the potential for bringing a pathogen into the hatchery is a serious concern to hatchery managers. As a precautionary matter, povidone iodine (1-ethyenyl-2-pyrrolidinone homopolymer and 1-vinyl-2-pyrrolidinone polymer iodine complex) is used routinely for disinfection of fish eggs in water that may potentially carry pathogens. Betadine® or PVP-Iodine is a commercial product that is 10% povidone-iodine (1% active iodine). The concentration of this stock solution typically used to disinfect salmonid eggs is 1% or 100 ppm of active iodine (Ross and Smith 1972; Amend 1974). While this concentration has been shown to be effective for controlling the majority of external bacteria and viruses in in-vitro tests (Amend and Pietsch 1972; Ross and Smith 1972; Chapman and Rogers 1992; Goldes and Mead 1995; Kumagai et al. 1998), the effect on Myxobolus cerebralis has not been tested. Vital staining has been useful for many applications, including the testing the viability of M. cerebralis (Markiw 1992).

A series of tests were conducted on triactinomyxons (TAMs), the infective stage of the salmonid parasite Myxobolus cerebralis, to determine the concentration of iodine needed to kill them. For each concentration, three to six replicate tests were conducted. For each test, 2 mL of the test iodine solution were mixed with 2 mL of TAM stock solution in a test tube and left at room temperature (15-20 C) for 10, 30 or 60 min. A minute or two before the time was up, the mixed solution was poured into a 10 um mesh filter to start filtering. At the allotted time, the filter retentate was rinsed with 20 mL of hatchery well water. This process took several minutes, after which 100 uL aliquots of retentate were transferred to 3-4 microscope slides. The slides were subsequently stained with 50-75 uL each of propidium iodide (52 mg/L) and fluorescein diacetate (100 uL of 5 mg/mL stock solution diluted with 8.3 mL hatchery well water). Control slides were made from the TAM stock solution and stained as noted above.

After incubation in a refrigerator for at least 45 min, the TAMs were observed by epifluoresence microscopy. The TAMs were classified as either red (dead), green (viable), or red and green (possibly viable).

The results of the iodine tests are presented in Table 1. Povidone-iodine concentrations of 50% or 5,000 ppm of active iodine for an hour were required to kill greater than 99% of the TAMs. This is 50 times the concentration typically recommended for treatment of fish eggs for bacterial and viral disinfection (McFadden 1969). The concentration of the stock solution was verified with a commercial colorimetric test. The same stock solution was used for all tests.

Clearly, higher concentrations of iodine are needed to adequately disinfect incoming water for M. cerebralis. The question becomes "How high can we safely go?" Amend (1974) tested the toxicity of Betadine and Wescodyne® (1.6% active iodine in the form of 9.1% polyethoxy polypropoxy polyethoxy ethanol-iodine complex, 8.74% nonylphenoxypolyethanoxyethanol iodine complex and 82% inert ingredients) to rainbow trout eggs. Amend (1974) found that toxicity was dependent upon pH and the stage of development of the eggs. At pH 6.9, the LC_{50} *for active iodine was 1480 ppm in a 15 min treatment or 1050 ppm in a 60 min treatment of eyed eggs. If the solution was buffered, the* LC_{50} *of eyed eggs was increased to greater than 2000 ppm at either pH 7.0 or 8.0. When eggs were water hardened in iodine, 25 ppm of iodine was safe, but 100 ppm resulted in significant mortality. Leary and Pederson (1988) noted reduced survival in rainbow trout eggs water hardened in 1.24% Betadine buffered to pH 8.0. If eggs were allowed to water harden for 30 min, Amend (1974) reported no significant impacts on egg mortality, hatchability, or abnormalities at concentrations of 25, 100, or 200 ppm iodine. McFadden (1969) noted that up to 2.5% povidone iodine for 10 min was not toxic to eyed rainbow trout eggs, but concentrations of 3, 4, and 5% (300-500 ppm iodine) resulted in eggs surviving less than 24 h (no pH given). Alderman (1984) noted that concentrations of iodine from 75 to 200 ppm at pH values of 6.5, 6.75, or 7.5 for 10 min were safe for eyed Atlantic salmon Salmo salar eggs. For eyed rainbow trout eggs, Alderman (1984) tested concentrations of 50 to 4,000 ppm iodine for 10 min at pH levels from 3 to 8 and found that the* LD_{25} *was about 800 ppm at pH 6.0 and in excess of 3000 ppm at pH 7.0. For freshly fertilized rainbow trout eggs, Alderman (1984) found that mortality was also highly variable among females; 800 ppm iodine (either 10 min post-fertilization or after 30 min of water hardening) resulted in nearly complete mortality for eggs from some females and less than 10% for others.*

Based upon the above research, achieving 5,000 ppm iodine without killing the eggs might be possible for eyed eggs at pH 8, but unrealistic for freshly fertilized eggs. Alternative chemicals for disinfection may be necessary. Glutaraldehyde was superior to iodine, chloramine-T, and sodium hypochlorite in treatment of plaice Pleuronectes platessa eggs (Salvesen and Vadstein 1995); concentrations of 400-800 mg/L for 5-10 min was recommended for Atlantic halibut Hippoglossus hippoglossus eggs whereas a shorter contact time (2.5 min) was recommended for Turbot Scophthalmus maximus (Salvesen et al. 1997). For treatment of largemouth bass Micropterus salmoides eggs, acriflavine (500-700 ppm for 15 min) was the disinfectant recommended by Wright and Snow (1975) over five other disinfectants.

Given the above data, exploration of alternative disinfectants may be necessary for prophylaxis against organisms such as M. cerebralis actinospores that may be carried with eggs into the hatchery. In the meantime, consideration should always be given to where water is dumped when bringing in eggs from the wild, taking care not to contaminate water supplies. When using iodophors, a fish culturist would also be wise to heed the recommendations of Chapman and Rogers (1992): use at least a 4:1 iodophor to egg volume ratio, make new solutions when treating multiple batches, and circulate the iodophor well during treatment.

Table 1. Mean percentage of non-viable, viable, and possibly viable triactinomyxons after exposure to various concentrations of povidone-iodine. Iodine concentrations are given as a percentage of the commercial povidone-iodine stock solution (10% povidone-iodine) and in active iodine concentration in ppm (given in parentheses). Control values were pooled.

Povidone-iodine concentration % (ppm active iodine)	Duration (min)	Dead (%)	Viable (%)	Possibly viable (%)	range of TAM numbers per replicate (n)
0.0 (0.0)		1.5	91.2	7.3	10-100 (24)
1.0 (100)	10	64.3	16.5	19.2	82-100 (3)
2.5 (250)	10	67.2	25.4	7.4	76-104 (4)
5.0 (500)	10	66.3	11.7	22.0	100-100 (3)
50.0 (5,000)	10	76.5	9.3	14.2	100-160 (3)
50.0 (5,000)	30	90.7	8.8	0.4	70-102 (3)
50.0 (5,000)	60	99.3	0.5	0.2	91-117 (6)

Literature Cited

Alderman, D.J. 1984. The toxicity of iodophors to salmonid eggs. Aquaculture 40:7-16.

Amend, D.F. 1974. Comparative toxicity of two iodophors to rainbow trout eggs. Transactions of the American Fisheries Society 103:73-78.

Amend, D.F., and J.P. Pietsch. 1972. Virucidal activity of two iodophors to salmonid viruses. Journal of the Fisheries Research Board of Canada 29:61-65.

Chapman, P.F., and R.W. Rogers. 1992. Decline in iodine concentration of iodophor during water hardening of salmonid eggs and methods to reduce this effect. Progressive Fish-Culturist 54:81-87.

Goldes, S.A., and S.L. Mead. 1995. Efficacy of iodophor disinfection against egg surface-associated infectious hematopoietic necrosis virus. Progressive Fish-Culturist 57:26-29.

Kumagai, A., K. Takahashi, S. Yamaoka, and H. Wakabayashi. 1998. Ineffectiveness of iodophor treatment in disinfecting salmonid eggs carrying *Cytophaga psychrophila*. Fish Pathology 33:123-128.

Leary, R.F., and J. Pederson. 1988. Effects of water-hardening eggs in a Betadyne or erythromycin solution on hatching success, development, and the genetic characteristics of rainbow trout. Population Genetics Laboratory Report 88/4, University of Montana, Missoula.

Markiw, M.E. 1992. Experimentally induced whirling disease II. Determination of longevity of the infective triactinomyxon stage of *Myxobolus cerebralis* by vital staining. Journal of Aquatic Animal Health 4:44-47.

McFadden, T.W. 1969. Effective disinfection of trout eggs to prevent egg transmission of *Aeromonas liquefaciens*. Journal of the Fisheries Research Board of Canada 26:2311-2318.

Ross, A.J., and C.A. Smith. 1972. Effect of two iodophores on bacterial and fungal fish pathogens. Journal of the Fisheries Research Board of Canada 29:1359-1361.

Salvesen, I., and O. Vadstein. 1995. Surface disinfection of eggs from marine fish: evaluation of four chemicals. Aquaculture International 3:155-171.

Salvesen, I., G. Øie, and O. Vadstein. 1997. Surface disinfection of Atlantic halibut and turbot eggs with glutaraldehyde: evaluation of concentrations and contact times. Aquaculture International 5:259-258.

Wright, L.D., and J.R. Snow. 1975. The effect of six chemicals for disinfection of largemouth bass eggs. Progressive Fish-Culturist 37:213-217.

Commercial Exhibitors

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Commercial Exhibitors

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Door Prizes and Donors

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List of Door Prizes and Donors

Contributor	Location	Door Prize
BioOregon, Inc.	Warrenton, OR	Knife
Black Sheep Sporting Goods	Lewiston, ID	Bushnell 10x50 Binoculars
Cabella's	Sidney, NE	wildlife print - deer
Christensen Networks	Ferndale, WA	Sweatshirts
Clearwater Drifters and Guide Shop	Orofino, ID	Drift boat trip for 2
DB Dun, Inc	Boise, ID	2 Custom Rod Cases
Decot Hy-Wyd Sport Glasses, Inc.	Phoenix, AZ	$50 gift certificate
Eagar, Inc.	N. Salt Lake, Utah	Fry Feeder
Familian Industrial Plastics		Jacket
Frame Gallery	Hood River, OR	Discounted framing
Franz Hardware	Hood River, OR	Pro-pocket Knife
Full Sail Brewing Company	Hood River, OR	2 hats, 1 vest, 1 water bag
Harper Brush Dist., Inc.	Renton, WA	Sof-Loc Fasteners, Harpers Newspage, Wash Brush, Fire Extinguisher, & Chocolate
Hood River Inn	Hood River, OR	Hood River Inn/Mt. Hood Meadows Ski package for 2
ICHY Prints	Boise, ID	5 fish print T-shirts, 1 Gyotaku linen print
Idaho Angler	Boise, ID	Guided Fishing Trip for 2
Intermountain Weighing Systems, Inc.	Boise, ID	Scale
Jensorter	Bend, Oregon	Maglite Kit
Joe Warren - author	Cook, WA	*Tying Glass Bead Flies* book and video
Leddy Potter	Quinault, WA	Guided Fishing Trip
Luhr Jenson & Sons	Hood River, OR	Mini Chef Electric Smoker
Mt. Hood Railroad	Hood River, OR	2 tickets for Mt. Hood RR
Pachmayr	Monrovia, CA	gift certificate for recoil pad
Paul Kaiser	Quilcene, WA	2 hand crafted boxes

Contributor	**Location**	**Door Prize**
Quinault Tribe	Tahola, WA	Canned salmon pkg.
Rangens, Inc.	Buhl, ID	Knife & baseball caps
Riverquest Excursions	Lewiston, ID	Hells Canyon Jet Boat Trip
Slate Run Galleries	Orofino, ID	Original, framed trout print
Sprint Telephone	Hood River, OR	25 five minute phone cards
Tater Bryson	Quinualt, WA	Guided Fishing Trip
The Gallery	Lewiston, ID	Steven Lyman Print "Naturally Idaho"
Water Management Technology	Baton Rouge, LA	Belt Feeder
Wenatchee River Salmon Festival	Wenatchee, WA	5 T-shirts, 4 sweat shirts, Peaceful Pond CD, *Discovering Salmon* Activity Book
White Salmon Water Adventures	White Salmon, WA	4 whitewater raft trip tickets
Yakama Nation	Cle Elum, WA	Yakama Nation Blanket

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Pacific Northwest Fish Culture Conference
Historical Record

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Pacific Northwest Fish Culture Conference
Historical Record

Year	Location	Host Agency	Chairperson
1950	Portland, OR	U.S. Fish and Wildlife Service	Ted Perry
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1952	Seattle, WA	Washington Department of Fisheries	Bud Ellis
1953	Portland, OR	Fish Commission of Oregon	Fred Cleaver
1954	Seattle, WA	U.S. Fish and Wildlife Service	Bob Rucker
1955	Portland, OR	Oregon Game Commission	John Rayner
1956	Seattle, WA	Washington Department of Game	Cliff Millenbach
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1958	Seattle, WA	Washington Department of Fisheries	Bud Ellis
1959	Portland, OR	Fish Commission of Oregon	Ernie Jeffries
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1961	Portland, OR	Oregon Game Commission	Chris Jensen
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